Study on Changes in and Consequential Effects of Surface Water Bodies of Brihospotipur and Adjoining Area of Santhia Upazila, Pabna, Bangladesh, Between 1970 and 2017.

This research report submitted to the Department of Geography and environment under the Faculty of Social Science, Jahangirnagar University, Savar, Dhaka, in partial fulfilment of the requirement for the degree of Bachelor of Science in Geography and Environment.

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Abstract

This study investigates the spatial distribution and changing patterns of surface water bodies in Brihospotipur and its adjacent areas, located in the active Ganges River Floodplain. This region has undergone significant wetland transformation due to the implementation of the Pabna Irrigation and Rural Development Project (PIRDP) in 1992, which aimed to mitigate riverbank erosion, control floods, and sustain agricultural development. The construction of flood control dams, irrigation channels, and drainage channels has led to the conversion of seasonal wetlands into dry lands, altering the natural alluvial fertilization process and affecting the region's biodiversity. This research identifies and classifies the types and areal extent of surface water bodies, detects the driving forces behind their changes, and explores the consequential effects on local communities. While the PIRDP has increased crop production and facilitated infrastructural development, it has also raised concerns about the loss of common resources, increased use of fertilizers and insecticides, and the disruption of traditional socio-economic practices. The study emphasizes the need for documenting wetland transformation at the local scale to inform sustainable management strategies that balance development with ecological preservation.

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Chapter One: Introduction

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1.2 Statement of the Research Problems
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1.7 Introduction

A wetland is an area that is saturated with water for any duration of time and plays a vital role as a resource. Riverine Bangladesh is rich in wetland in terms of extent and its biodiversity. In Bangladesh, more than 2/3 parts of the total area are considered as wetland (Nishat et al., 1993). It includes rivers, streams, Khal, Beel, Pond, Ditch, etc., and they are subject to change over time. Man converts this wetland by their activities in such a way that the wetland loses their natural characteristics and fails to fulfil their functional cycle. This conversion is known as the transformation of Wetland. Wetlands are transforming mainly in two ways: natural and human induced. Natural changes take place slowly and do little harm, but changes brought out by human interaction are rapid and, most of the time, harmful.

Surface water is used for a variety of purposes, including agriculture, household, fisheries, irrigation, transportation, aquatic habitation, ground water recharge, microclimatic regulation, and so on. Many rural people seriously rely upon wetland resources for their livelihood. But in the last three decades, extensive transformation has occurred in the wetland and seriously threatened the biodiversity, natural environment, traditional polyculture, and socio-economic practices (Nishat et al., 1993).

Pabna Irrigation and Rural Development Project (PIRDP) was developed in 1992, and the aims were to mitigate riverbank erosion, control food, and sustain agricultural and fisheries development. Under this project, 158 km flood control dam, 25 km irrigation channel and 145 km drainage channel were constructed (Bangladesh Water Development Board, 2005). Due to this man-made construction, wetlands become dry land, perennial wetlands become seasonal wetland, and seasonal wetland become dry land or perennial wetland.

As a result it occurs settlement expansion, infrastructural development, increase in the cultivable land and crop production occur. As it increases the irrigation facility, farmers can be able to produce crops three times in a year. Previously, it was used only one or two times for crops. On the other hand, most of the lands become flood free, it decrease the areal extent of water body, common resources become private property, marginal people become loser. Fertilizer and insecticide use here increased, causing harmful effects on the biodiversity of this area. Besides that, land use and crop rotation also change.

1.2 Statement of the Research Problems

The study area is the active part of the Ganges River Floodplain. It was naturally flooded and functioned as alluvium land. Agricultural land is uniformly fertilized in natural ways. Soli contained sufficient moisture to grow crops. Relatively low lands were flooded in the monsoon season, and they became common properties to the marginal people. In the dry season, this land was used for agricultural production. There was an equilibrium that circled rhythmically. But in 1992, the Pabna Irrigation and Rural Development Project (PIRDP) was developed for flood control. In this project, local rainwater is pumped out regularly to inundate the land. The water level of drainages and canals is controlled and also effectively checks the riverine flood water by a high embankment known as Mujib-Badh. As a result, the seasonal flooded and deathly flooded lowlands that remain 4 to 6 months under water up to a depth of 90 to 180 cm are no longer inundated. Extensive floodplain that turns into wetlands have now become dry land. For this reason, the conditions of the biodiversity of this wetland are seriously affected. A broader environmental issues upraised in this area. On the other hand, it produces an additional 1 lakh and 91 thousand metric tons of crops per year, providing irrigation facilities in more than 18 thousand and 680 hectares of land (Bangladesh Water Development Board, 2005).

Taking advantage of flood-free conditions, new households are emerging rapidly. Due to the shift of the water level, it had to shift the agricultural land. One crop land became two or three crop lands, and crop production gradually increased. Non-flooding conditions do not help enrich soil with new silts, and farmers are facing some issues in the new conditions. They are trying to adapt to this new condition. My study greatly emphasizes understanding the nature of new conditions, the processes of the transformation of the wetland and agriculture, land use shifting processes, and related issues and understanding how the farmers handle the issues.

1.3 Justification of the study

Wetland transformation took place in the study area, and many socio-economic and environmental issues were also upraised. On the other hand, people find some additional advantages in agriculture, habitation, land use, and fisheries. As wetland transformation is deeply related to other socio-economic and environmental issues, sometimes wetland transformation occurs by development activities, and sometimes development activities are accelerated by wetland

transformation. So, if we can trace out the transformation of wetlands, we may be able to find the changes of other relevant occurrences.

But at the local scale, the state of wetland transformation is limited. Driving factors of wetland transformation are site-specific and variable. Therefore, it needs documentation and updating at a regular pace of wetland transformation.

1.4 Research Question

1. What is the variety of surface water bodies in the area?
2. Where are they located?
3. What is the areal extent?
4. How significant are they to the local people?
5. How are they being used?
6. What are the characteristics of the water bodies?
7. How are they being changed?
8. What are the driving factors for transformation?

1.5 Aim and Objectives of the Study

Aim

The study aims to know about the spatial distribution and changing pattern of surface water bodies of Brihospotipur and the adjoining area.

Objectives

1. To identify, classify and areal extent of the surface water bodies;
2. To detect the changes and driving forces of change of surface water bodies; and
3. To explore the consequential effect of changes of the surface water bodies there on.

1.6 Literature Review

Wetlands or water bodies means lowland that are the areas which include river, marsh, fen, lake, cannel, pond, ditch, peatland or water that can be natural or artificial, permanent or temporary, static or flowing, fresh, brackish or salt lakes, ditches and marine water; the depth of which at low tide does not exceed 600 cm from the major part of the year (Ramsar Convention on wetland, 1971). A wetland is a place that has been wet enough for a long time to develop specially adapted vegetation and other organisms (Maltby, 1986)

Wetlands are characterized by three perimeters: Hydrology –There must be water at or near the surface of the land for a designated amount of time; Soils –Must be hydric or saturated with water to create an oxygen-free environment. Plants –Must be wetland plants (Smith & Smith, 2001).In this sense, 2/3 of the total land and 56% of the total agricultural lands of Bangladesh are included in wetland as they are temporarily inundated with water for a considerable period (Alam, M.S. et al 2003).

Rivers, streams, shallow freshwater lakes and marshes, floodplains, inshore coastal areas, haors, baors, beels, water storage reservoirs, fish ponds, and flooded cultivated field, lakes, dighis, deep water paddy fields are considered as wetlands (GOB 2001; Alam, M. S. and Chowdhury, H. M. 2003)

Surface water bodies mean discrete and enclosed parts of water such as a lake, a reservoir, a stream, river, or canal, part of a stream, river, or canal that are mainly brackish. Surface water bodies are the part of wetland; where wetland can be saline or maritime but surface water bodies must be brackish (Thomas, J. 2016)

Significant of Wetlands

Wetlands are invaluable elements of the natural environment, ecology, potential resources, and biodiversity in Bangladesh. They are an undivided part of the local ecosystem-based cultures. Wetlands play as vital link between land and water. Most of the people in Bangladesh are critically dependent on wetlands. Wetlands play a vital role in maintaining the ecological balance of ecosystems. It also supports agriculture, fish, and natural vegetation and maintains soil structure

that is distinctive from that of surrounding uplands, and vegetation also varies between upland and wetlands (Talukder, B. et al. 2009)

Bangladesh has more than 700 rivers and streams, thousands of shallow freshwater lakes and marshes, floodplains, and extensive estuarine systems as haors, baors, and beels, water storage reservoirs, fish ponds, and flooded cultivated fields (Alam, M. S. and Chowdhury, H. M. 2003). About 6.7% of Bangladesh is always under water, 21% is deeply flooded (more than 90 cm), and 35% experiences shallow inundation (FAO 1988).

Bangladesh is rise in wetland, it about 7,497 km2 of rivers, 1,142 km2 of beels and haors, 45,866 km2 of floodplains are exposed to inundation, 1,469 km2 of ponds, 72,899 km2 of brackish-water farms and 55 km2 of baors or oxbow lakes (Akonda, A.W. 1989; Khan S.M. et al. 1994).

Wetlands are the most productive ecosystems. Countless species of plants and animals largely depend on wetlands for their survival of life. A high concentration of fishes, amphibians, reptiles, birds, mammals, and invertebrate species are supported by this wetlands (Khan S.M. et al.. 1994). Rice, cultivated in wetlands (beels and baors) is the main food in Bangladesh. Wetlands also provide important ecological functions and socio-economic services and contain very rich components of biodiversity of local, national, and regional significance (Talukder, B. et al.. 2009).

Wetlands can be thought of as biological supermarkets. It is estimated that, about 5,000 species of flowering plants and 1,500 species of vertebrates in Bangladesh, up to 300 plant species and some 400 vertebrate species are judged to be dependent on wetlands for all or part of their lifespan. Wetlands play a role as a habitation for a variety of resident and migratory waterfowl, one-third of threatened and a significant number of endangered species (Khan S.M. et al.1994 and United States Environmental Protection Agency/EPA).

Natural wetland perform many important functions for humankind and lives such as storm prevention, control of water flow, replenishment of groundwater, nutrient and waste absorption, formation of sand bars, flood prevention, alluvial soil deposition, feeding and breeding grounds for birds, pollution filtration, prevention of desertification, promotion of luxurious growth of vegetation and have an important role in recreation and aesthetic appreciation, navigation, religious and ritual performances (Barbier, E. B. 1992 and Mandal, R. B.)

Classification of Wetland

Wetlands can be classified into different types. By the basis of its origin, wetlands can be natural and manmade. Wetlands can be classified by the basis on its chemical properties, inundation level and time, landscape position, vegetation cover and hydrologic regime, hydro-geomorphic properties of geomorphic setting, water source, and hydrodynamics (Brinson, M.M. 1993)

Given the diversity of wetland environments, the U.S. Fish and Wildlife Service adopted Cowardin et al. (1979) classification schemes. At the highest level are five wetland systems: Marine- Open Ocean, continental shelf, including beaches, rocky shores, lagoons, and shallow coral reefs. Normal marine salinity to hypersaline water chemistry; Estuarine- Deepwater tidal habitats with a range of fresh-brackish-marine water chemistry and daily tidal cycles. Salt and brackish marshes, intertidal mudflats, mangrove swamps, bays, sounds, and coastal rivers; Riverine- Freshwater, perennial streams comprised of the Deepwater habitat contained within a channel; Lacustrine- This system includes inland water bodies that are situated in topographic depressions, lack emergent trees and shrubs, have less than 30% vegetation cover, and occupy at least 20 acres (8 ha). Includes lakes, larger ponds, sloughs, lochs, and bayous; Palustrine- All non-tidal wetlands that are substantially covered with emergent vegetation- trees, shrubs, moss, etc. Most bogs, swamps, floodplains, and marshes fall into this system, which also includes small bodies, as well as playas, mudflats and salt pans that may be devoid of vegetation much of the time (Cowardin, L.M 1979)

In 1993, Brinson introduced the hydro-geomorphic (HGM) wetland classification system, and the US Army Corps of Engineers developed it based on three factors- geomorphic setting, hydrology, and hydro-dynamics. HGM classes are limited to the following approved classes: Riverine, Depression, Slope, Mineral soil Flats, Organic soil Flats, Estuarine Fringe, Lacustrine Fringe (United States Department of Agriculture, 2008)

Under the Ramsar Convention 1979, wetland types have been defined in different categories. They are: a) Marine or Coastal Wetlands- Permanent shallow marine waters, Marine subtidal aquatic beds, Coral reefs, Rocky marine shore, Sand, shingle or pebble shores, estuarine waters, Intertidal mud, sand or salt flats, Intertidal marshes, Intertidal forested wetlands, Coastal brackish or saline lagoons, Coastal freshwater lagoons and Karst and other subterranean hydrological systems; b)

Inland Wetlands- Permanent inland deltas, Permanent rivers or streams, Seasonal or irregular rivers or streams, Permanent freshwater lakes, Seasonal freshwater lakes, Permanent saline, brackish or alkaline lakes, Seasonal saline, brackish or alkaline lakes, Permanent saline, brackish or alkaline marshes and pools, Seasonal saline, brackish or alkaline marshes and pools, Permanent freshwater marshes, Seasonal freshwater marshes, Non-forested peatlands, Alpine wetlands, Tundra wetlands, Shrub-dominated wetlands, Freshwater, tree-dominated wetlands, Forested peatlands, Freshwater springs and Geothermal wetlands; c) Human-made wetlands- Aquaculture ponds, Ponds, Irrigated land, Seasonally flooded agricultural land, Salt exploitation sites, Water storage areas, Excavations, Wastewater treatment areas, Canals and drainage channels, ditches etc. (Ramsar Conversation on Wetland, 1979)

However, in this study, wetlands are classified into five major types. They are river, khal, beel, doba and pond. All of them are brackish.

Wetland Management

During the pre-British period, the wetlands were traditionally managed by the people living around them. The local community evolved and enforced various complex and localized tenurial systems for harvesting fisheries resources (Capistrano et al., 1994). During the British period, the wetlands came under the control of Zaminders (Land Lords) as a part of their revenue-earning estates. In 1950, when the Zaminder system was abolished, the government got the ownership of most of the wetlands. But over the centuries, the wetlands in Bangladesh have been providing wider opportunities for the millions of rural people to make up their livelihood. The access arrangements to wetlands for fishing are very complex and varied from place to place. Generally, people enjoy the traditional rights for own consumption, but sometimes it is permitted clandestinely, sometimes the owner overlooks consumption fishing by the poor; People are allowed to pick up any fish left after the Final harvesting by the lessor or owner. The lessor or owner allows a share of the catch (Rahman, M. M.).

Now, the Bangladesh Water Development Board (BWDB) is the main government body managing the wetlands. As the principal agency of the government for managing the water resources of the country, it was given the responsibility of accomplishing the tasks of executing flood control, drainage, and irrigation projects to boost productivity in agriculture and fisheries. A good number of Non-Government Organizations are also working for the betterment of lakes. The activities of

NGOs include flood control, natural resource conservation, livelihood development, farming and irrigation programs, etc. Among these NGOs, CNRS, IDEA, BCAS, AOSED, BRAC, Prosika, Nijera Kari, Samata, etc., are well-known (Chakraborty, T.R.)

During the 1990s, Bangladesh realized the needs of resource management seriously, and from then, the management and conservation of those water bodies got priority. Although the status of nations' wetland management initiatives is not at a satisfactory level but in some cases, the success is appraisable. In the water management of Bangladesh, it is strongly addressed in the crop sector as the growing population demands more food (Nishat, A. 2003).

In the study area, most of the privet waterbodies, such as ponds, doba, nala, etc., are managed by single or multiple efforts. But the river is controlled by leaseholders in the dry season, and beels are controlled by leaseholders in the monsoon. As a common property, marginal people get access in the monsoon season when water bodies become a single body.

Threats of Wetlands

Most of the resources of Bangladesh, highlight the enormous value of wetland ecosystems and at the same time they warn about the threats that the wetlands of the country have been experiencing. In Bangladesh, wetlands are considered an invaluable component of ecosystems when people find no economy values. But wetlands support a large number of flora and fauna, and shape the society and culture of rural Bangladesh (Uddin et al 2013 and Rana et al 2010). Despite this importance, the wetlands of Bangladesh are facing serious challenges from environmental changes and anthropogenic disturbances (Sarkar, 1993; Nair, 2004; Ahmed et al 2008). As the population of the country has increased the wetland resources of the country have come under pressure. Over exploitation has already decimated fish stock and other aquatic plants and animals (Rana et al 2009) The major threats of wetland in Bangladesh are population growth that change the physical and chemical properties of water, extensive agriculture and urbanization that reduce of wildlife, expansion of human habitation and agriculture in the wetlands that threat many species of flora and fauna, conversion of wetlands that ruined aquatic plants, ill-planned national and rural infrastructures like roads and culverts displaced and affected fish diversity, over-fishing and over-cutting of wetlands, siltation due to degradation of the associated watershed areas, increased use of fertilizer and pesticide, indiscriminate regulation of flows of river, pollution of water due to industrial, urban, agrochemical and other and change of hydrological condition (Byomkesh T. et al 2008).

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Chapter Two: Data Sources and Methodology

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2.1 Data Collection Sources

Objectives	Data	Data source
Objective-1	Location, types and areal extent of surface water bodies	Field survey Administrative records Mouza maps Published and unpublished data
Objective-2	**a.** Identification of changes occurred e.g.: location, form, shape, size and association **b.** Causes of changes	Field survey, SRDI report consultation, historical data interpretation, mouza maps, published and unpublished data
Objective-3	Impact on natural and human environment (to what, to whom, to where, to when, to how)	Field survey, SRDI report consultation, historical data interpretation, published and unpublished data

2.1.1 Primary Sources of Data

2.1.2 Primary data sources refer to direct field surveys, which have been collected in flowing ways: Field Survey, Field Observation, Formal Interview, Informal Interview, Photography Collection, GPS reading, and discussion.

2.1.3 Secondary Sources of Data

Relevant books, articles, reports, unpublished theses, maps, relevant documents, newspaper cuttings, and relevant journal are the major sources of secondary data.

2.2 Research Methodology

Methodology is the systematic and logical study of the principles guiding scientific investigation. It follows scientific methods, systematic observation, classification, and interpretation of data.

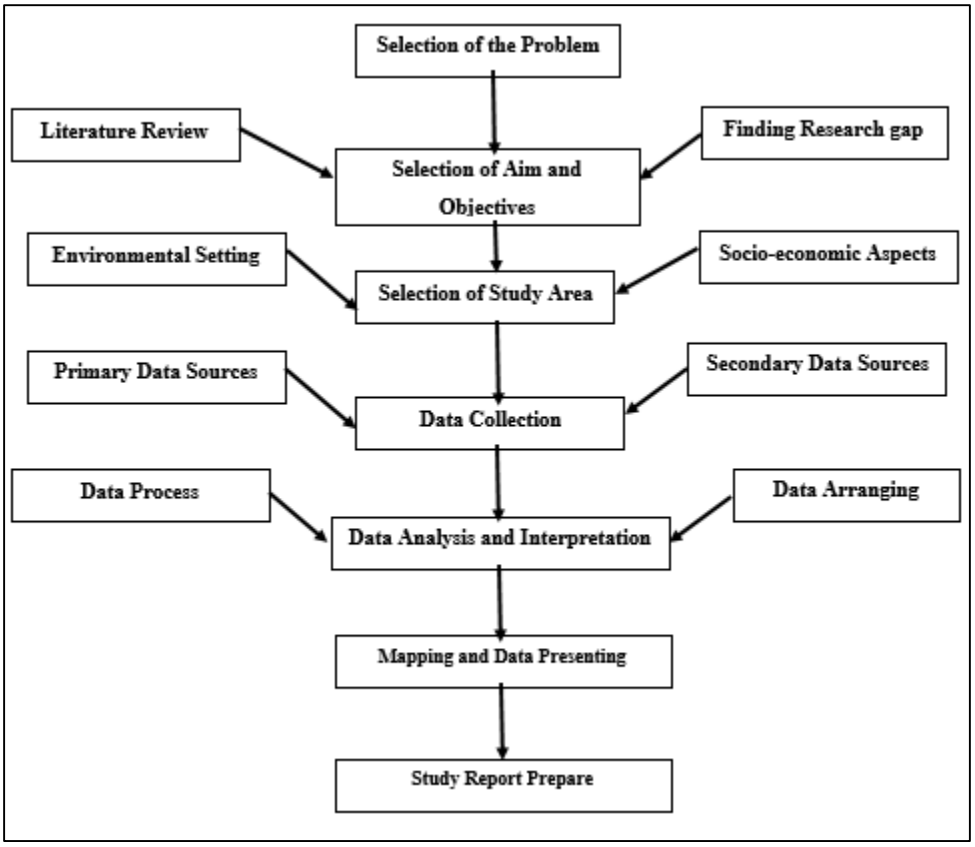

Figure: Methodological flow chart of the study

2.3 Google Image Interpretation

Google Image or Aerial photography interpretation is the early step that has been down before the field survey. After selecting and bounding the study area, it deeply interpreted the different components and features within the study area. Especially, surface water bodies or wetlands were effectively identified by Google Earth Pro. To identify the wetlands, their aspects, association, distribution, pattern, and areal extent, I have followed some indicators. The indicators are Size, Regular shape, Irregular shape, Tone or Color, Pattern, Shadow, Association (with settlement), Road Aline (along the roadside), and lowland area (beside the marsh land).

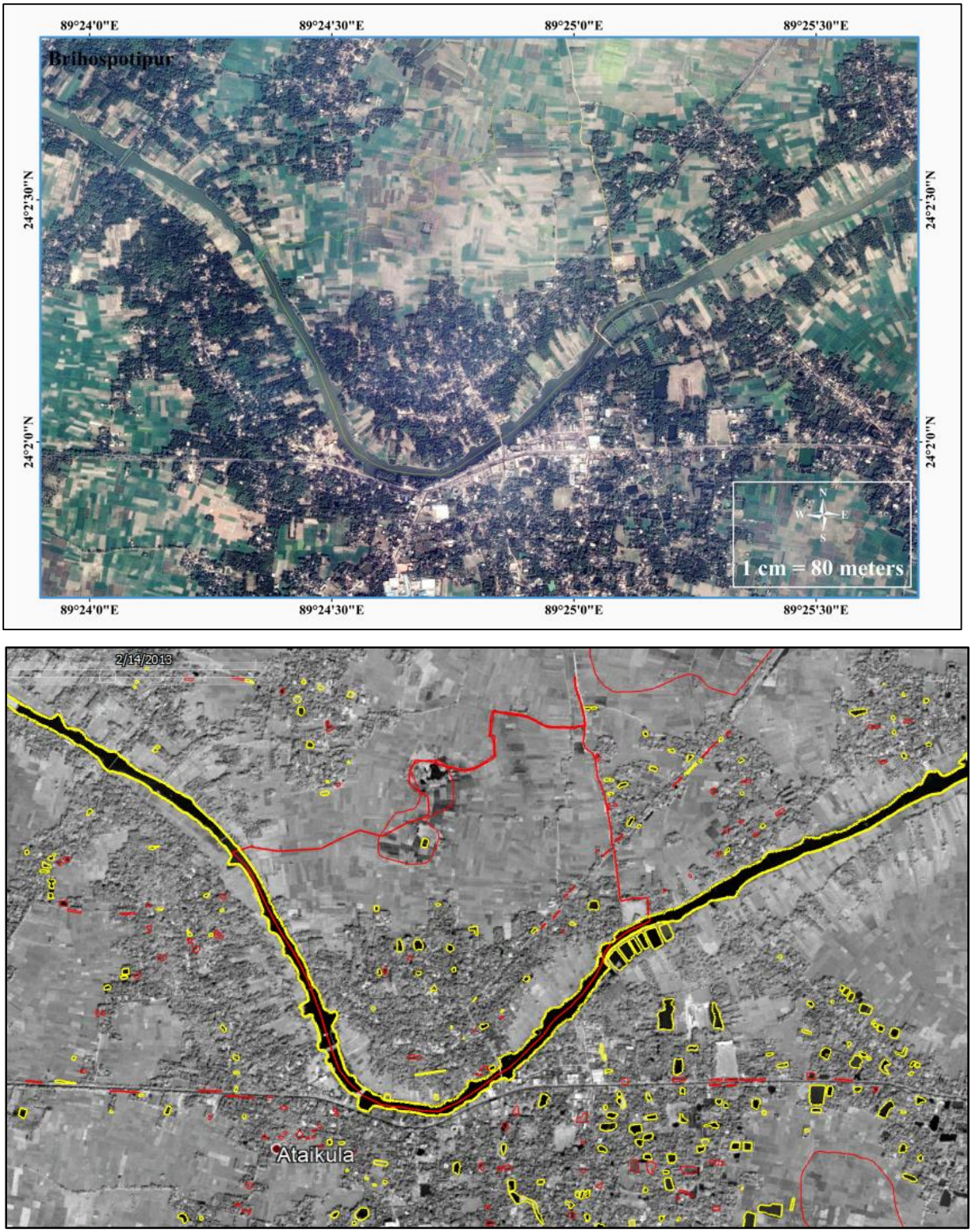

Figure: Aerial photo interpretation

2.4 Presenting Base Map

The base map is a depiction of the background that references the information such as landforms, road networks, landmarks, channel patterns, physical and cultural features, political boundaries, etc.

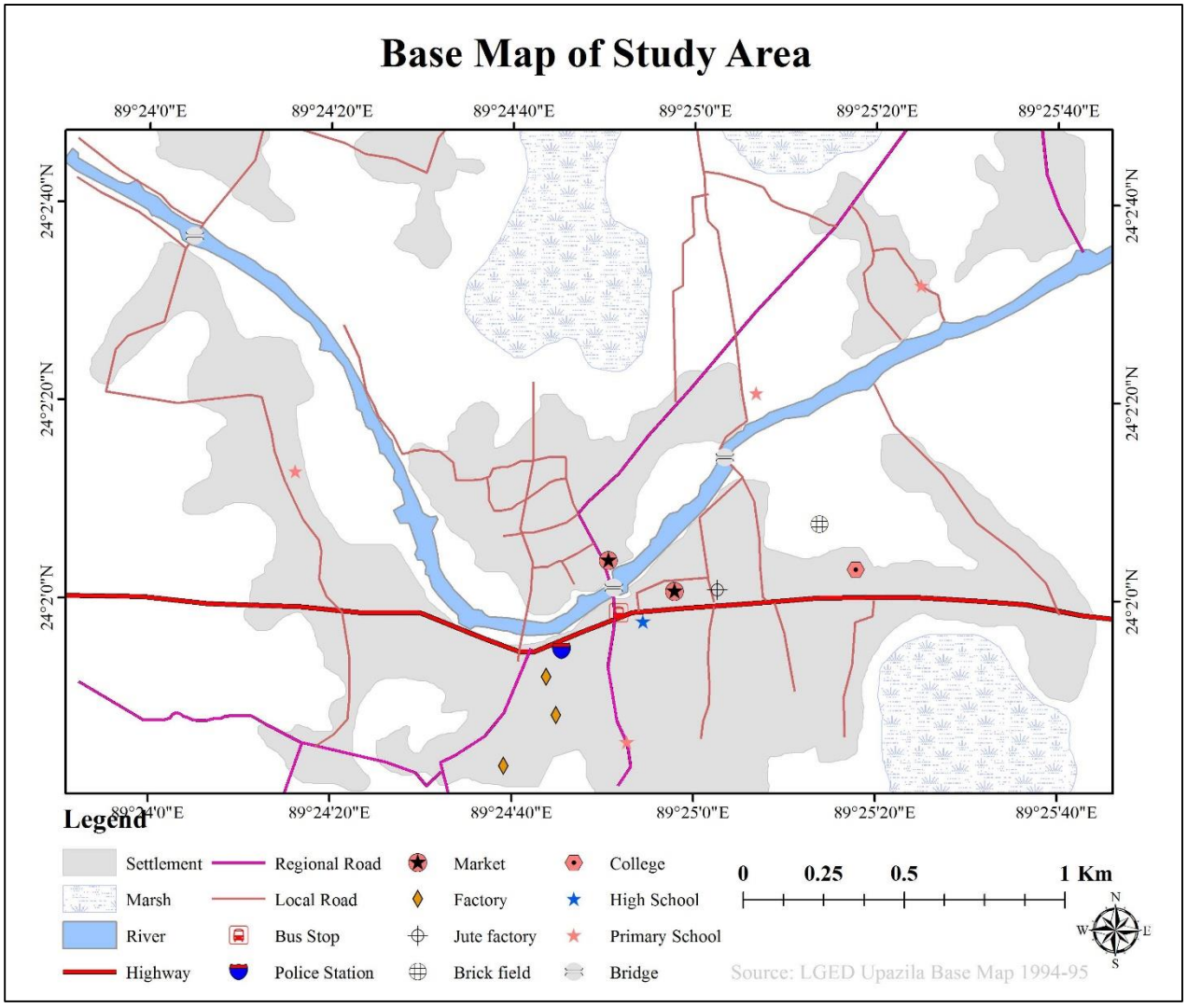

Figure: Base Map of study area

2.5 Developing Draft Question

By the basis on the knowledge of base maps, aerial photo interpretation, field observation, and literature review, a draft question sheet was developed. To fulfil the aim and objectives, the question sheet was converted into a tabulate sheet. The tabulate sheet was about the existence of

surface water bodies. It also holds information about the origin, nature, types, characteristics, ownership, management, and uses of wetlands within the study area.

Inventorying Surface Water Bodies of Brihospotipur and Adjoining Area

S.L	Verification		Types of Water Bodies					Year of Construction	Character of water Bodies		Ownership			Management			Uses					Comments
												Privet										
	Yes (1)	No (2)	River (1)	Khal (2)	Bell (3)	Doba (4)	Pond (5)		Perennial (1)	Seasonal (2) (time)	Government (1)	Single (2)	Multiple (3)	Single (1)	Multiple (2)	Cooperative (3)	Household (1)	Irrigation (2)	Industry (3)	Fisheries (4)	Others (5)	

Figure: Tabulate Sheet of field survey

2.6 Reconnaissance Survey

A Reconnaissance Survey is a type of field survey that was used to gather initial information regarding the presence and absence of historic properties within the study area. It is down in order to get familiar with the information about the study area. The purpose of this survey was to know about the climatic, physiographic, geologic, hydrologic, and ecologic information of the study area. To know the areal distribution, aspects, and orientation of physical and cultural features was another aim of this survey.

2.7 Participatory Field Observation

Participatory Field Observation is done for the helps to help ground truthing and make it easier to verify the real state of the study area. In this step, many valuable information were listed down

from the field that help to understand the current situation of the study area. To identify the uses of different types of wetlands, this field observation plays an important role.

2.8 Informal Interview

The local people are not always ready for a formal interview. Most of the people feel comfortable talking informally and in free local dialogue. They inform their issues to others by gossiping, and it needs no fixed time and place. It can be in the morning, can be evening or night, on vehicles, on the way of field, market and any place or time. But it can be very effective to gather information. Wetlands data was collected in this way also.

2.9 Focus Group Discussion

Focus group discussion helps to know about the background history of present land form, Muzib-Badh, Pabna Rural Development and Irrigation Project, historical flood, pre-FCDI condition, present and past crops production, causes of digging pond and different ideas of local people. Many historical stories transforming head to head in rural area and they are information based and have reality. Many aged and experienced people informed some information that is not documented and almost abolished. FGD helps to find the change that occurred in the study area.

2.10 Photography

Photography is a strong tool that represents the present condition of the field. Data was captured from the field directly, which helped to interpret the study area. The relationship between man and environment can be dawn by photography. Sometimes, it is not possible to observe the study area detail, then photography helps to make this task more easer. Some collected photographs contain valuable information about water bodies.

2.11 Field Visit

A large number of raw date ware collected by field survey. The individual water body that was identified on Google Maps was verified by the field survey. Simultaneously, other necessary data were successfully collected by the tabulate data sheet. During the field survey, some marked water bodies that were identified on Google Maps no longer existed in the field. On the other hand, nearly half of the total number of water bodies were identified in the real world by the field work that did not exist on Google Maps. It is noticeable that the field survey was down in the peak wet season, and most of the seasonal wetlands were found alive and kicking.

2.12 Field Data Processing and Analysis

To fulfil Objective-1 (Location, types and areal extent of surface water bodies) and Objective-2 (Identification of changes occurred e.g.: location, form, shape, size and association; Causes of changes), some specific data were gathered from the study area. It calculates the collected data and arrange it as possible as it can. First of all, it identified the waterbodies on Google Earth images. Then, trace them on the skin according to their shape, size, and association. The following indicators were followed to identify the water bodies: color, regular shape, regular shape, association and road aline to identify the water bodies. 199 water bodies were identified properly, and 7 others no longer existed. and 126 new water bodies were identified. The total number of water bodies is now 325.

2.13.1 Characteristics of Wetland

The founding water bodies are categorized into two major sectors. They are 'Natural Water Bodies' such as River and Beel or Marsh and another is 'Manmade Water Bodies' such as Khal, Doba and Pond. The main waterbody, River is perennial and the common property of this area as well as seasonal Beels. Most of the ponds are perennial, and they are used for household and fisheries. Most of the Khal, Beel, and Doba are seasona.

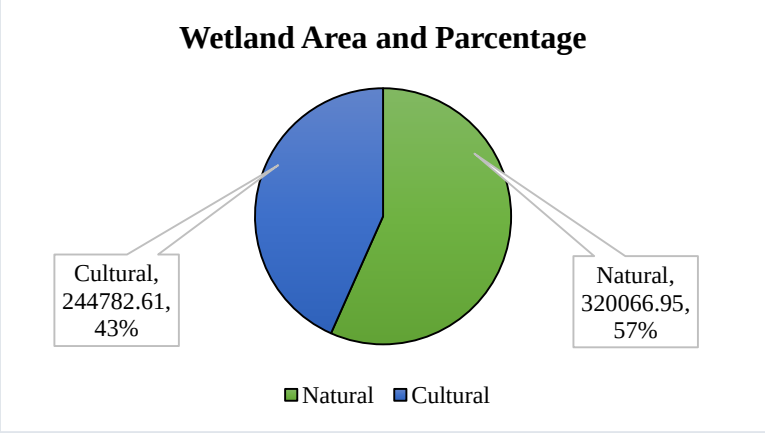

Figure: Wetland Area and Percentage According to Nature

2.13.2 Types of Wetlands

The major identified waterbodies are rivers and Beels as natural features; Khal, Doba, and Pond were found as cultural features. Ponds are the major feature in this area that making up about 35.53%, and then Perennial rivers occupy 30.65 and seasonal beels are 26.02%**.** Area of River is 173104.6 meters^2, Beels are 146962.1 meters^2, Khals are 85516.5 meter^2, Dobas are 35516.5 meters^2 and Ponds are 200669.9 meters^2.

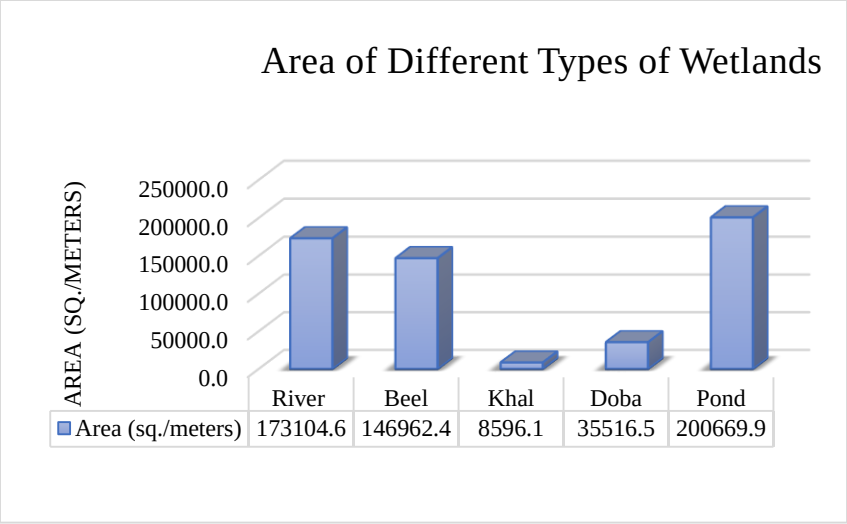

Figure: Area of Different Types of Wetlands

2.13.3 **Origen of Wetlands in-between 1970 and 2017**

By processing and arranging this data, an organized tabulate data as well as different diagrams were found. On or before 1970, there were only 29 wetlands in this area, that's about 336466.28 meters2, most of them are natural. Between 1971 and 1980, 27655.62 meters2 of land was transformed into wetland, 21900.66 meters2 transformed in-between 1981 and 1990, 134063 meters2 in-between 1991 and 2000, 42829.27 meters2 in-between 2001 and 2010, and only 1934.36 meters2 transformed from 2011 to 2017. Due to the massive flood in 1998 it increase the transformation of land into wetland in between1991 and 2000.

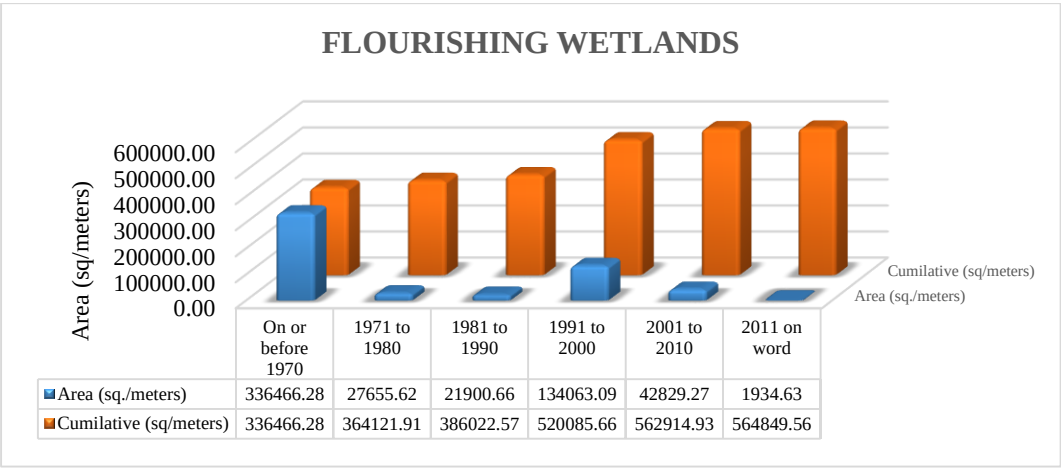

Figure: Origen of Wetlands in-between 1970 and 2017

The total area of wetland was gradually increasing till 2010 and then suddenly fall. The possible causes can be use of existing wet lands by reshaping and re-digging in different purpose.

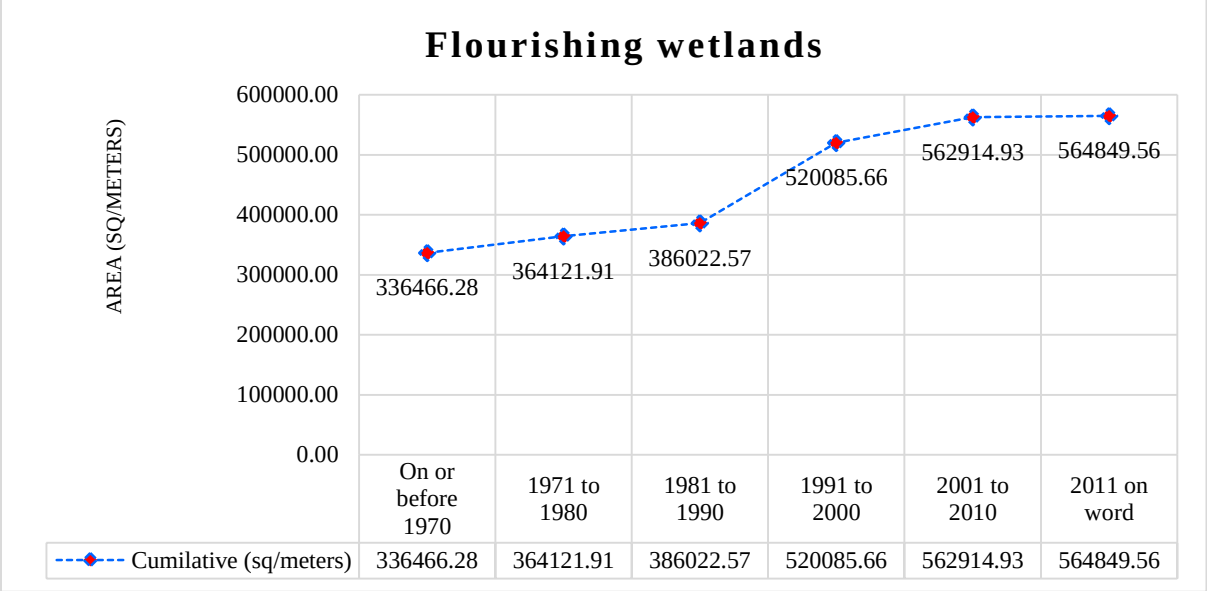

Figure: Flourishing Wetlands in-between 1970 and 2017.

2.13.3 Characteristics of Wetland

By the availability of water in different times of the year, wetlands are divided into two major types. Perennial Wetland and Seasonal Wetland. Seasonal wetlands are also divided into two types they are S1 (Seasonal: June to February) and S2 (Seasonal: July to October). There are 168 perennial about 374921.71 meters2; 62 Seasonal (June-February)/S1 water bodies, about 162922.45 meters2; and 95 Seasonal (July-October)/S2 water bodies, about 26516.40 meters2 in the study area. Almost 62 seasonal wetlands hold water from early rainy season to late winter (June to February), and other 95 hold water only in late rainy season (July to October).

According to the pie chart, we can see that 66 percent of water bodies are perennial; they hold water year round, and most of them are used for household and fisheries. On the other hand, only 29 percent of waterbodies hold water for almost 6 months (June to February) in the rainy season. Another 5 percent only inundates in depth rainy season (July to October).

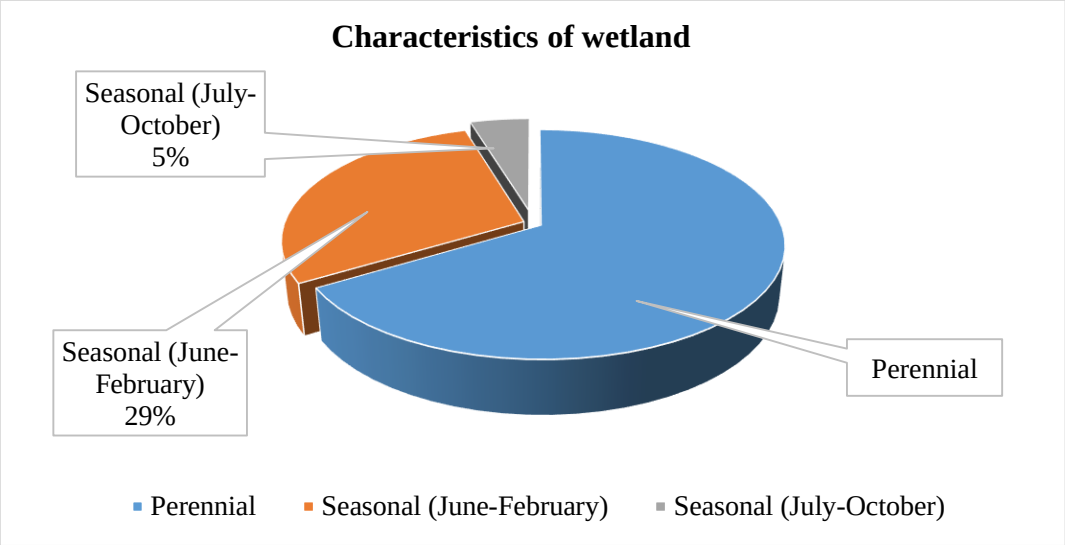

Figure: Percentage of water bodies by their characteristics.

2.13.4 Ownership of Wetlands

There are three types of ownership found for the existing water bodies in this locality. Among them, 37.61 percent are multiple ownership, most of them management by joint venture, 31.13 percent are single ownership that managed by landholder. And 31.26 percent are government properties that act as common property and are used in various ways.

Rivers and Beels are the major common properties in this area. Beels are seasonal, but the river is used as a common property year-round. Marginal people use Beels as a common properties traditionally but the excess gradually reduce day by day. Constructed ponds are taking place in this area, and they become personal properties. As a result, it endangered the local flora and fauna. As constructed wetland is only used for commercial purposes, the local fish cannot grow there.

Table: Number of wetlands and their ownership

Types of Ownership	Number	Area (sq./meters)	Percentage
Government	12	176576.8445	31.26%
Single	151	175824.122	31.13%
Multiple	162	212448.5941	37.61%
Total=	325	564849.5605	100%

2.13.5 Management of Wetlands

Most of the privet waterbodies are managed by single or multiple efforts. However, the common properties are managed cooperatively. Nearly 180748 square/meters is managed by a single effort, 113327 square meters is managed by Multiple, and the rest, 270773 square meters area is managed cooperatively. According to the criteria of management, the wetland management proportion is- 47.9 % are cooperative, 32% are single, and 20.1 % are multiple management.

Management of Wetlands	Area (sq./meters)	Percentage (%)
Single	180748.44	32.0
Multiple	113327.42	20.1
Cooperative	270773.70	47.9
Total=	564849.56	100%

2.13.6 Uses of Wetland

Water bodies are used in various ways. Most of all are used in household, fisheries and others e.g. bathing, transportation, performing of ritual etc.

Table: Number of wetland and their uses

Uses of Wetland	Number	Area (sq./meters)	Percentage
Household	289	545123.70	96.51%
Irrigation	57	258378.81	45.74%
Industry	4	180290.68	31.92%
Fisheries	197	526050.17	93.13%
Others	260	534102.44	94.56%
Total=	325	564849.56	100%

Total Area of weatland are 564849.56 meters^2 that use in many ways. The percentage of use of wetland given below-

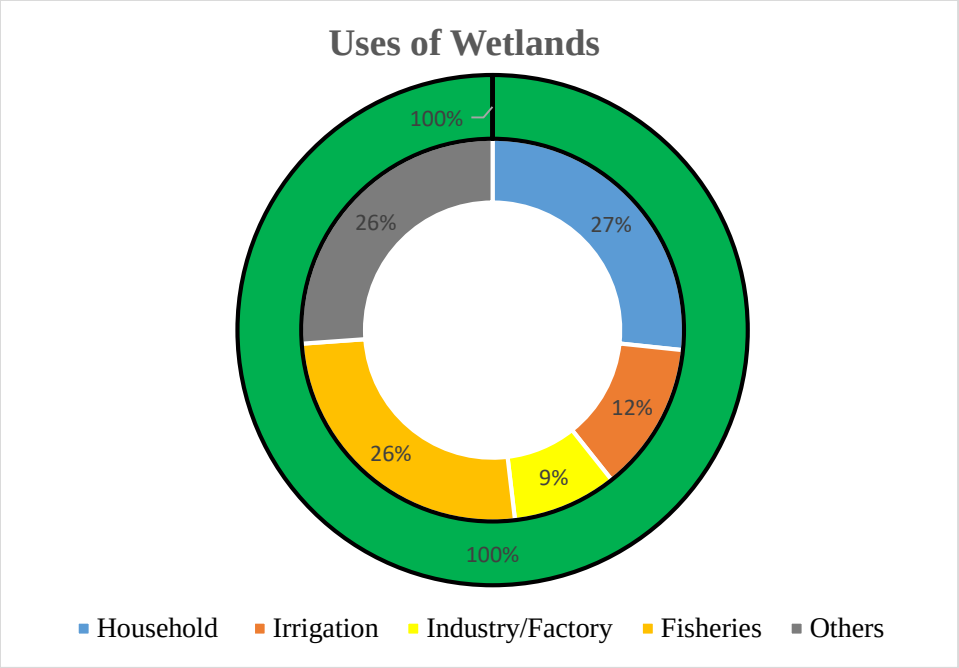

Figure: Percentage of wetland and their uses

3

3

Chapter Three: Study Area

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3. Study Area Selection

The first step of a research work is area selection. My study area is Brihospotipur and its adjoining area, which is situated in the Pabna district in Bangladesh. Brihospotipur and its adjoining area, the part of Santhia, Atghoriya, and Pabna Sadar Upazila of Pabna District is the fertile land of the Ichamoti River. Mainly, it is the part of the Ganges River Floodplain. It is about 8 meters above sea level and covers 6.59 square kilometers extended.

3.1. Location

Relative Location: Brihospotipur is located 20 kilometers east of Pabna. Daponiya and Garuliya Mouza of Atghoriya Upazila to the north, Shoradangi Mouza of Pabna Sadar Upazila to the West, Ataikula and R-Ataikula Mouza of Pabna Sadar Upazila to the south, and Shibpur Mouza of Santhia Upazila to the East.

Absolute Location: It is located between 24°2'51.39"N to 24°2'50.61"N and 89°23'52.98"E to 89°23'52.97"E.

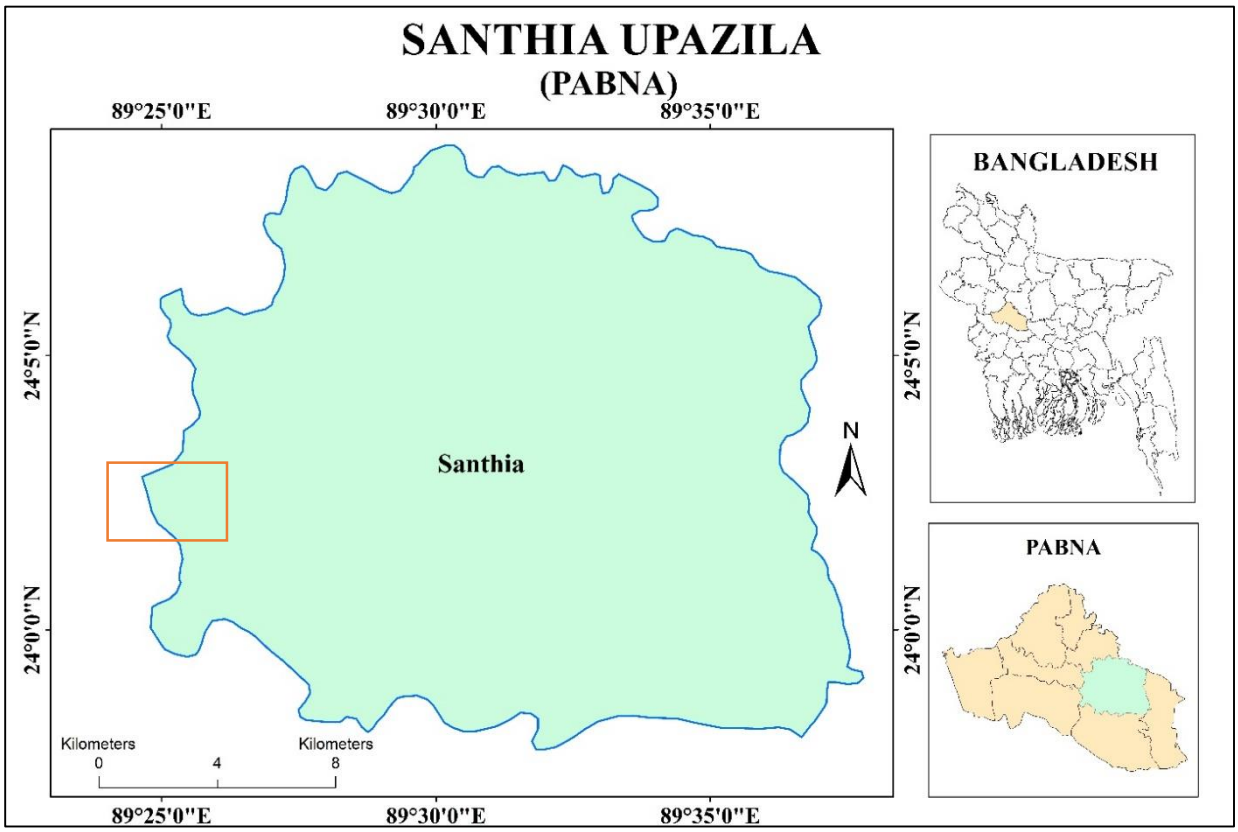


Fig: Map of Brihospotipur (Santhia, Pabna)

3.2. Physical Environment

The physical environment of the study area is as same as the physical environment of the northern part of Bangladesh. The study area is the part of the deltaic plain that is subject to frequent flooding. Although the landform is almost plain but it appears to have some relative high land and marsh land. There is no climatic variation in this area, it include in monsoon climate. The soil of this area was formed in the Pleistocene period, and most of them are silt and clay. The soil contains a huge amount of philosopher (Alim A. 2013). Ichamoti River is the main channel of this area, and other seasonal narrow and shallow channels are spread out inthe study area that connects the marshes.

3.2.1.Climate

The climate of an area means the precipitation, temperature, humidity, wind movement, air pressure, cloud, sun shine and other condition that exist in this area over the noticeable period of time. The climate of an area directly controls the growth of natural vegetation and the production of crops.

The study area, Brihospotipur, belongs to the 'tropical monsoon' climate as same as the rest part of the region. The three seasons, summer, winter, and rainy season are effectively circulate through the year along with the other three seasons of Bangladesh. Winter starts in early November and goes way into late February. This season is most driest and coldest but has a little precipitation. The mean temperature at this time is about 19°C, and the mean precipitation is about 33 mm. Between March to May, it is considered as summer when air become very hot and found little moisture. April is the hottest month about nearly 40°C temperature particularly in the north-western part of Bangladesh, and the study area is the part of this region. Sometimes, hail storms and northwester appear as hazards to the people. Man and livestock lose their life due to thunder or lightning. Between June to October, 90 percent of the total precipitation occurs in this area. The rainy season dominates the activities of local people, people are confined in a narrow place due to schedule flood. The level of humidity is about 76.8% in April and about 85% in July (District Statistics 2011, Pabna)

A chart was prepared by the Soil Research Development Institute (SRDI) based on weather-related data from the Bangladesh Meteorological Department (BMD) showing the mean temperature (°C) and mean precipitation (mm) against each month.

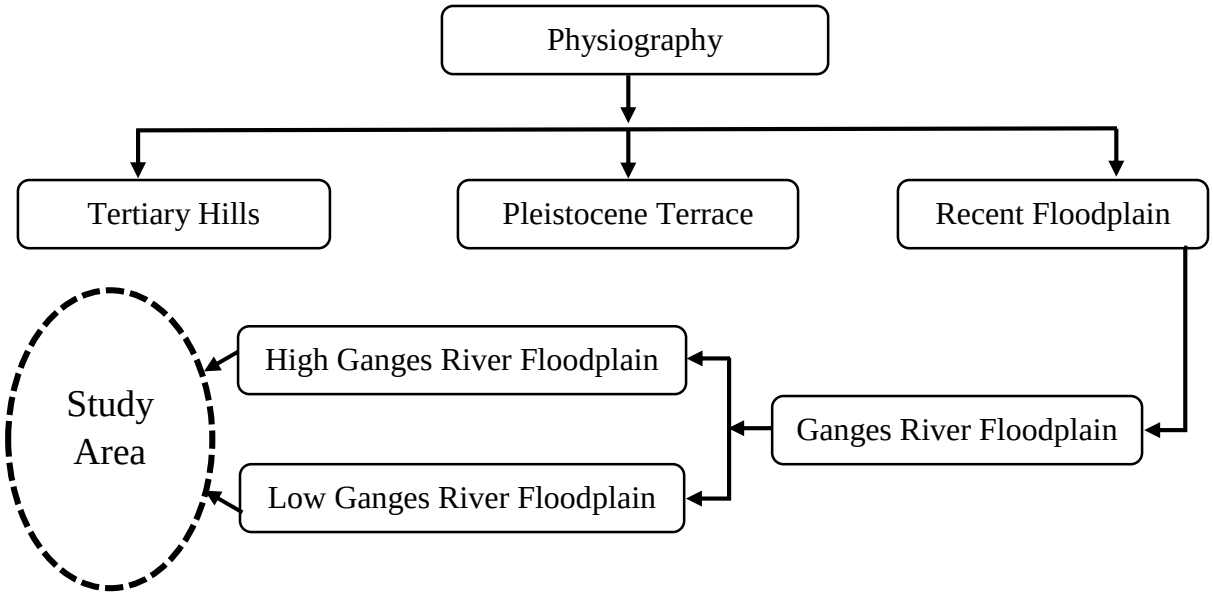
Table: Show the mean temperature (°C) and precipitation (mm) for each months in study area.

Weather Components ↓ / Month →	January	February	March	April	May	June	July	August	September	October	November	December	Yearly
Mean Temperature (°C)	18.6	21.0	25.8	29.4	29.8	29.4	28.8	29.0	29.1	27.6	23.3	19.7	25.9
Mean Precipitation (mm)	10	4	35	85	176	321	281	325	223	96	12	5	131

Source: SRDI Report: Santhia, Pabna, 1992

The physiography of the study area is mainly included in the 'Ganges River Floodplain' in the large-scale classification published by SRDI. This area is further generalized by agricultural science as the part of 'High Ganges River Floodplain' and 'Low River Floodplain.

Soil science also identifies this area as a part of Mixed Highland, Shallowly Flooded, and Deeply Flooded Phases.



However, in this study, according to the elevation and inundation level of the landforms, I have tried to classify the landforms into five major types. They are: Natural Levee, Point Bar, Lower Back slope, Marshes, and River Channel. The natural levee is the highest part of land in this area that is not flooded. Though it flooded, the water receded in a short period of time. The point bar is subject to flood, as it is the lower part of the river valley. Point bar inundates in the pre-flooding moment and be water free at last comparing to other parts of land.

The lower back slope is the agricultural land regularly saturated and flooded in the monsoon season, but the inundation level is considerable. Marshes in the natural depression of this area that is flooded in the rainy season and become a single body of water in the peak wet season. Ichamoti River, the only one perennial natural water bodies in the study area, play an important role in maintaining hydrological and other functional activities.

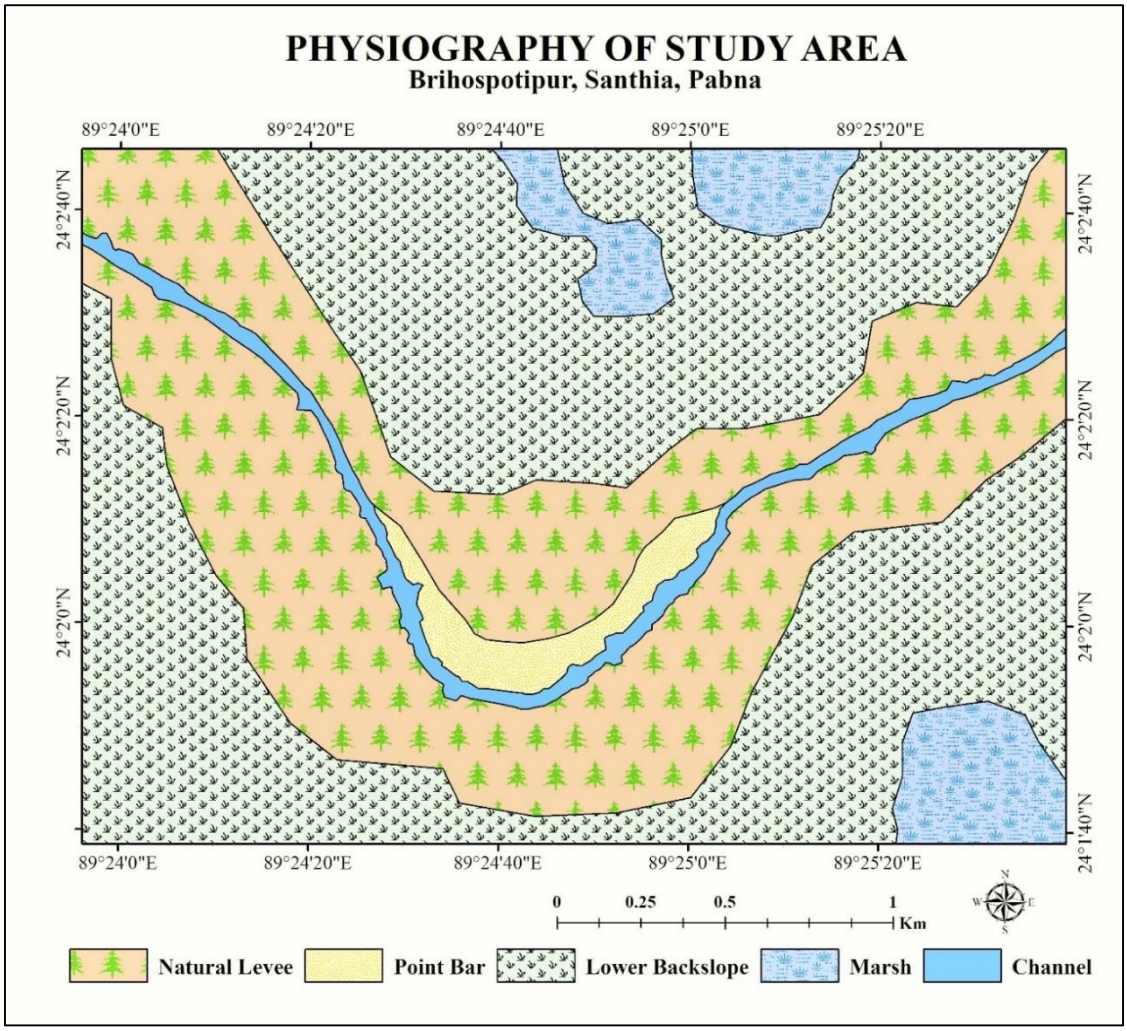


Fig: Physiographic map of Brihospotipur mouza.

3.2.2.Soil

The soil is the unconsolidated material or mineral on the immediate surface of the earth that serves as a natural medium for the growth of plants. It is the outermost solid layer of the earth.

The study area is the part of 'Gangeyo Palal Land' by the 'Seven Soil Tract' of Bangladesh. (Banglapedia, 2003). In the preliminary survey of Bangladesh Soil Research Institute, several types of soil are found in this area. In the study area, they found the soil pH+ range is 7.4 to 7.9 and the amount of organic matter is 1.48%. The mean amount of Calcium (Ca), Phosphorus (P) and Boron (B) are high and the mean amount of Magnesium (Mg), Potassium (K), Copper (Cu), Manganese (Mn) and Nitrogen (N) are low (SRDI Report: Santhia, Pabna, 1992).

Soil Color: According to the 'Munsell Color Chart', the soils of the study area are: Gray, Light Gray, Light Brown Gray, Gray Brown, Drack Gray Brown, Reddish Gray, Drack Reddish Gray, Drack Gray, Blackish, Blackish Gray, Reddish Black, Paly Brown, Paly Yellow, Olive, Paly Olive, Light Yellow Brown, Light Olive Brown, Olive Brown, Very Paly Brown, Light Brown, Light Radish Brown, Deep Brown, Very Deep Brown, Deep Yellow Brown, Red, Paly Red, Blackish Red, Very Blackish Red, Green Gray, Gray Green, Paly Green, Light Bluish Gray, Bluish Gray, Deep Bluish Gray, Mixed Color Etc. (SRDI Report: Santhia, Pabna, 1992)**.**

Soil Texture: Soil texture indicates the relative content of particles of sand, silt, and clay in the soil. Soil texture is very important for cultivation. Although there are 12 types of soil textures in the Soil Texture Triangle Diagram introduced by the US Department of Agriculture, the Soil Resource Development Institute of Bangladesh found only five categories of soil texture in the study area. They are:

Sand Soil- more than 70% sand, less than 30% silt and less than 15% clay;

Sandy Loam Soil- 43% to 80% sand, less than 50% silt and less than 20% clay;

Loam Soil- sand are less than 52%, more than 28% silt, less than 27% clay;

Clay Loam Soil- less than 70% sand, less than 73% silt and 20% to 40% clay;

Clay Soil- less than 65% sand, less than 60% silt and more than 35% clay.

Water Extraction: By the basis on water remove and water extraction soils of the study area can be divided into five categories. They are: Excellent, Good, Moderate, Low and Very Low

3.2.3.Drainage System

The drainage system is the natural or manmade removal of surface water in an area. It is also known as a river system that is formed by the rills, gullies, streams, rivers, canals/canals, lakes, ditches, and other sources of water in a particular basin.

The study area, Brihospotipur, is the part of the Ichamoti-Atrai river basin. A perennial river, the Ichamoti, and several canals flow over the study area. They link the marshes and other water bodies in the rainy season area, but they become almost dry in summer and are not navigable except in the rainy season. A huge number of rills, gullies, streams, canals, and ditches are spread out in this area and play a vital role in draining out the accumulated rainwater. As a result, land remains water logging free. The river discharges this water rapidly and saves form flood**.**

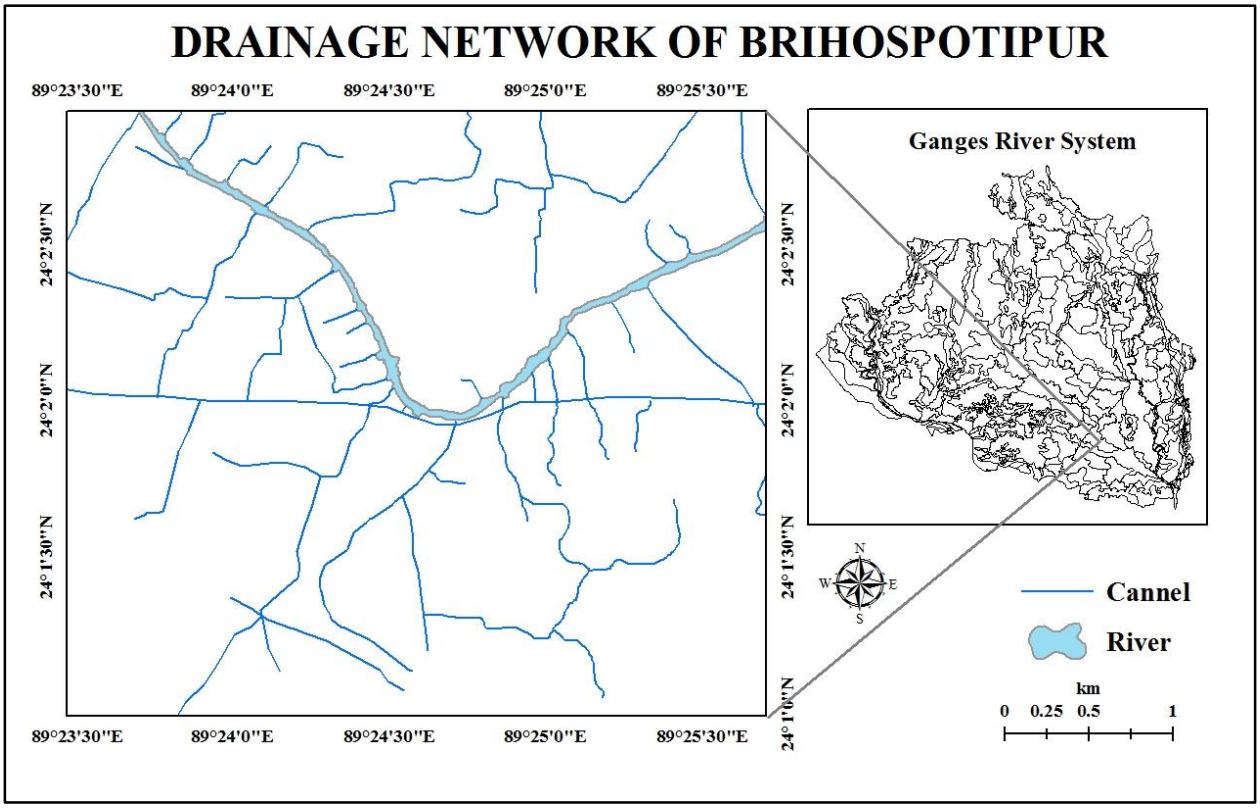


Fig: Drainage network of Brihospotipur and adjoining area

3.3. Cultural Environment

A cultural environment is a set of beliefs, practices, customs, and behaviors that are found to be common to everyone that is living within a certain population. Cultural environments shape the way that every person develops, influencing ideologies and personalities (Harry Moss, 2016)

Our lifestyle, dress, food, festivals, program, language, music, accommodation, art, jewelry, vehicle, utensil, belief everything make our culture. The culture of this area is composite and, over the centuries, has assimilated influences of Islam, Hinduism, and Christianity. It is manifested in various forms, including music, dance, and drama; art and craft; folklore and folktale; languages and literature; philosophy and religion; festivals and celebrations; as well as in a distinct cuisine and culinary tradition. (Wikipedia)

3.3.1.Population

The total population of Brihospotipur is about 2699, where the number of total males is about 1374 and the number of total females is about 1325. The sex ratio is 100:104. The present population growth rate is 2.37%. There are 769 people per square Kilometer. The literature rate is about 46%, where males are 44.3% and females are 47.9%. In the religious aspect,t 100% people of this village believe in Islam (Community Report: Pabna, 2011 and BBS)

Table: Percentage of population in different age group of Brihospotipur.

Age Group	Percentage (%) of Population
0 - 4	11.1
5-9	13.2
10 - 14	10.3
15 - 19	6.7
20 - 24	10.7
25 - 29	11.0
30 - 49	23.6
50 - 59	6.4
60 - 64	2.8
65+	4.8

Source: Population and Housing Census-2011, BBS

More than 34% are child between 0 to 14 age group, 51% people are young between 15 to 49 age group and rest 15% are adult.

3.3.2.Housing and Settlement

Housing refers to houses or buildings collectively or the accommodation of people. And settlements are organized groupings of human habitation. Settlements may include hamlets, villages, towns, and cities.

According to the Population and Housing Census-2011, the total number of houses in Brihospotipur is about 631. By the process of urbanization and population growth human settlement gradually expanded along the roadside and existing settlement. Settlements are rapidly changed from Kutcha to Semi-Pucka, Semi-Pucka to Full Pucka.

Condition of Household: In this village, 1.9% houses are full Pucka, 7.4 % are Semi-Pucka, and 90.6% are Kutcha, and a small number of Jhupri house.

Table: Condition of household in Brihospotipur.

Condition of House	Full Pucka	Semi-Pucka	Kutcha	Jhupri
Percentage (%)	1.9%	7.4%	90.6%	0.1%

Source: Population and Housing Census-2011, BBS

Toilet Facility: 25.8% houses have Sanitary Toilet with water seal, 70.2% houses have Sanitary Toilet with no water seal, 1.1% house have Non-Sanitary Toilet and 2.9% house have no toilet yet (Population and Housing Census-2011).

Table: Percentage of household comprising of the number of person.

Number of Person	Household (%)	Average size of Household
1	0.2%	4.3
2	8.4%	
3	21.9%	
4	34.9%	
5	18.5%	
6	7.9%	
7	4.8%	
8+	3.5%	

Source: Population and Housing Census-2011, BBS

3.3.3.Transportation System

A transportation system can be defined as the combination of vehicles, infrastructure (rail, road, station, junction, port, etc.), and operations that enable the movement or satisfy the travel demand of people and goods within a defined region. It is also known as the road network. The road network of this area consists of National Highways, Regional Highways, and District Roads. The transportation system of this area is enough developed to transport products from local market to towns. The Upazila towns are connected by local and regional roads. The National Highway, the Dhaka-Pabna road, is a busy road in this area that connects Pabna with the capital of Bangladesh. There are two Regional Roads in this area that connect the two Upazila with Ataikula and Brihospotipur. One is the Ataikula-Faridpur road that connects Ataikula Thana with Faridpur Upazila, and another is the Ataikula-Shujanagar road that connects Ataikula Thana with Shujanagar Upazila.

In the rainy season, due to the schedule flood water way transportation system emerge as a wall transportation media in the remotest part of this region. Bus, track, Micro Bus, car, CNG, Auto van, rickshaw, Auto rickshaw, motor bike etc. are the common vehicles in this area.

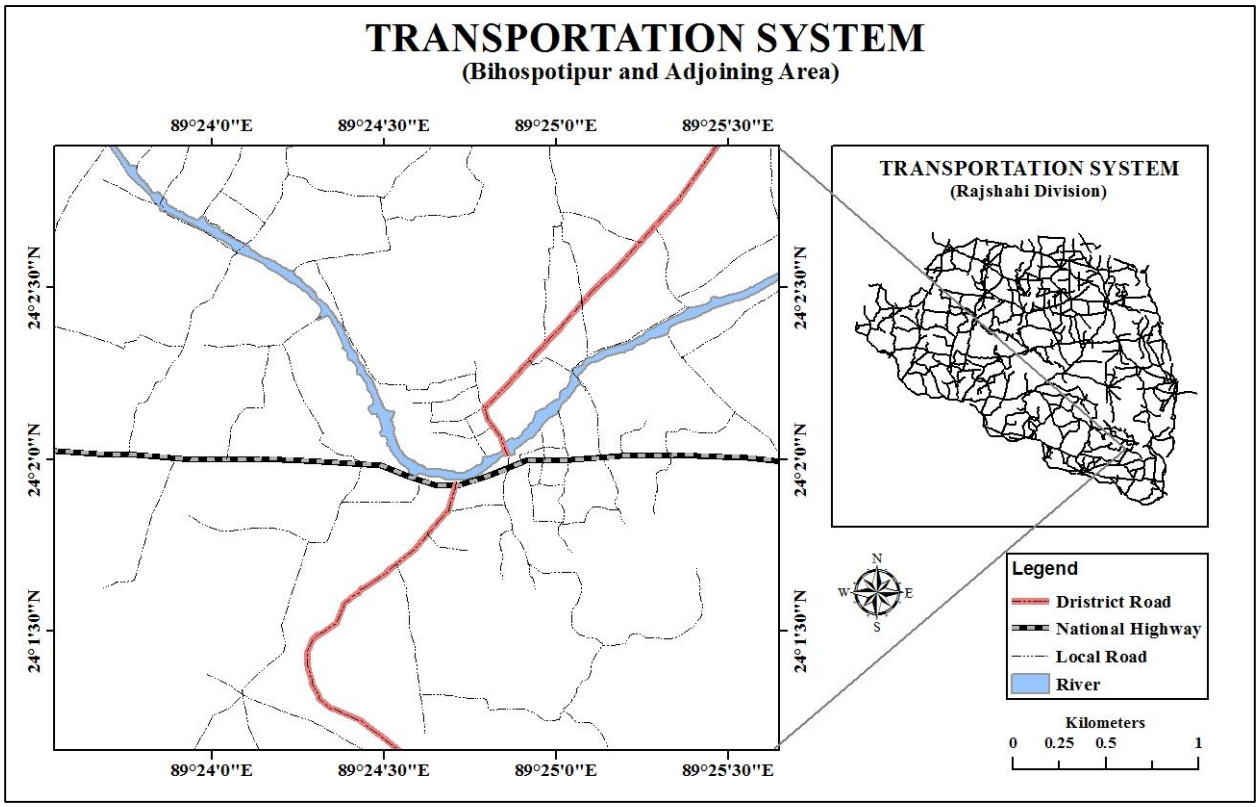
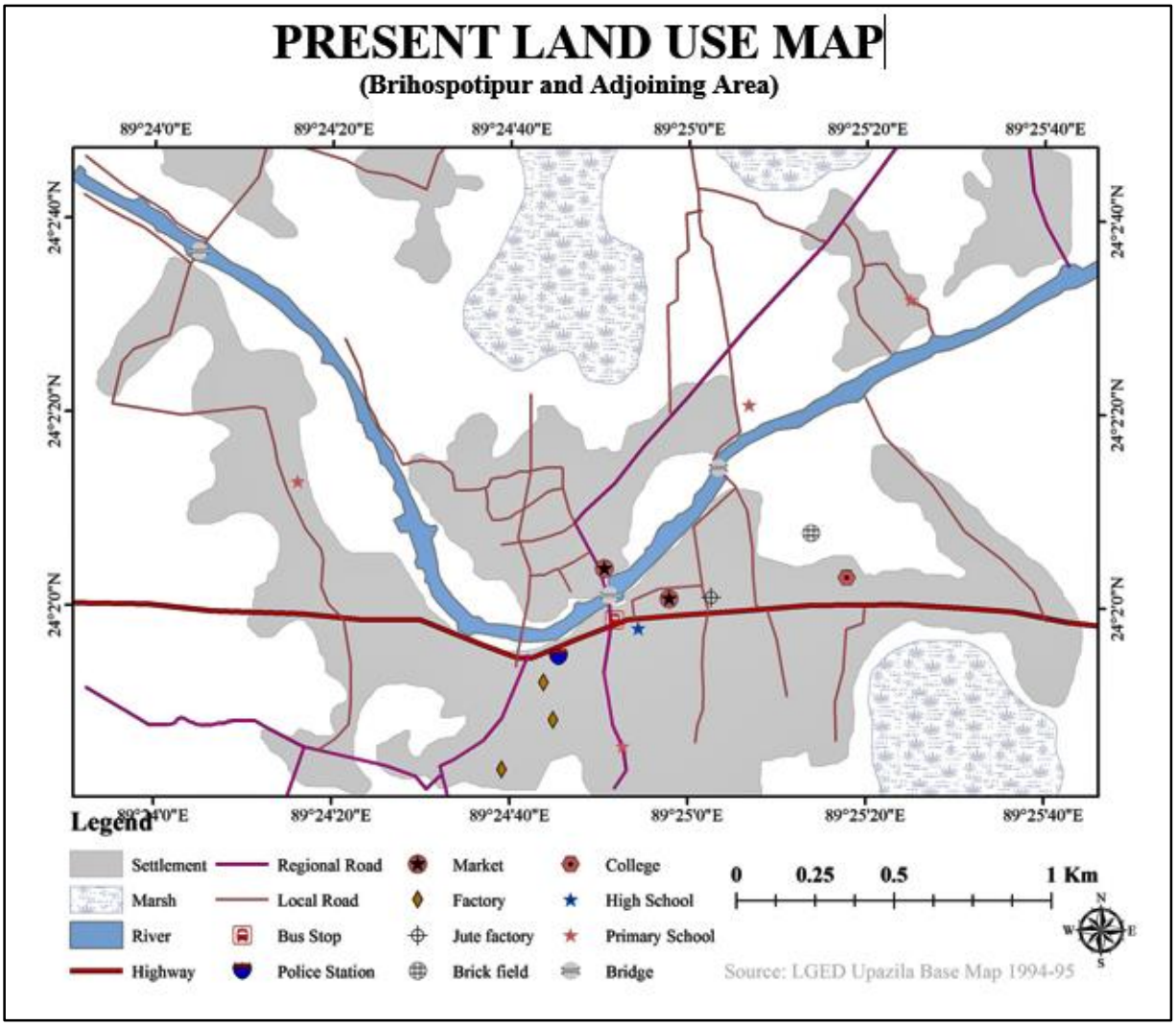


Fig: Transportation System of Brihospotipur and adjoining area.

3.3.4.**Present Land Uses** (2017-18)

Lands are used in various ways such as human settlement, transportation, forestry, industry, and agriculture. In the study area, most of the lands are used for settlement and cultivation.

In this area nearly 5 percent land remain uncultivated due to human settlement and other. More than 40 percent of lands are cultivated in the 1st Kharif season for Aush or Jute or Til (sesame) and other Rabi crops. Nearly 20 percent of lands are used for cultivating Aush or Jute in the 1st Kharif season, Ropa Amon in the 2nd Kharif season, and other crops in the Rabi season. Another 15 percent of lands are used for Ropa Amon in the 2nd Kharif season and Boro in the Rabi season. Only 10 percent of lands are used for vegetables or seasonal fruit. The remaining 10 percent of lands are used for cultivating annual and biennial crops such as Sugarcane, turmeric, or others (SRDI Report: Santhia, Pabna, 1992).



Source: (Moderate from) LGED Upazila Base Map 1994-95

3.3.5.Socio-Economic Condition

The economy of the study area is predominantly agricultural, and 53.06% of holdings are farms, which produce varieties of crops, namely local and HYV Aus, Aman, Boro, Wheat, Pulses, Oil Seeds, Sugarcane, Spices and Condiments, Vegetables, and other minor crops. Livestock farming is another important source of income for the people of this area. Various fruits like mango, jackfruit, litchi, jam, palm, banana, guava, watermelon, etc., are grown here. Varieties of fish are caught from rivers, beels and paddy fields during rainy season. The most common fishes are Ruhi, Katal, Mrigel, Magur, Singi, Koi, Puti, Shoil, Gozar, Boal, etc. There are some other varieties of fish are Pangas, Airh, Chingri, Batasi, Bacha, Kholisha, Rita etc. All these fishes are economically valuable (District Statistics 2011, Pabna).

People are involve in Manufacturing, Electricity, gas, water supply, Construction, Wholesale & retail trade, Hotels and restaurants, Transport, storage and communication, Bank, insurance and financial institution, Real estate and renting, Public administration and defense, Education, Health and social work, Community, social and personal services (District Statistics 2011, Pabna)

In 2010, the World Bank published a poverty map named "Zila level povmap estimates, 2010" that mentions the percentage of extremely poor (lower poverty line) and Poor (Upper poverty line). In this report, the study area had 17.5 % extreme poor (lower poverty line) and 31.1% Poor (Upper poverty line)**.**

4

Chapter Four: Surface Water Bodies of the Study Area

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4. Surface Water Bodies

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4.2. Characteristics of Surface Water Bodies

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4.6. Ownership of Wetlands

4.7. Management of Wetlands

4.8. Uses of Wetland

5. Surface Water Bodies

Surface water bodies mean discrete and enclosed parts of water such as a lake, a reservoir, a stream, river, or canal, part of a stream, river, or canal that are mainly brackish. Surface water bodies are the part of wetland; where wetland can be saline or maritime but surface water bodies must be brackish (Thomas, J. 2016)

Wetlands or water bodies means lowland that are the areas which include river, marsh, fen, lake, cannel, pond, ditch, peatland or water that can be natural or artificial, permanent or temporary, static or flowing, fresh, brackish or salt lakes, ditches and marine water; the depth of which at low tide does not exceed 600 cm from the major part of the year (Ramsar Convention on wetland, 1971). A wetland is a place that has been wet enough for a long time to develop specially adapted vegetation and other organisms (Maltby, 1986)

4.9. Identification of Surface Water Bodies

The individual water body was identified on Google Maps and verified by the field survey. Simultaneously, other necessary data were successfully collected by the tabulate data sheet. During the field survey, some marked water bodies that were identified on Google Maps no longer existed in the field. On the other hand, nearly half of the total number of water bodies were identified in the real world by the field work that were not exist on google map. It is noticeable that the field survey was down in the peak wet season, and most of the seasonal wetlands were found alive and kicking.

Surface water bodies or wetlands were effectively identified on Google Earth Pro. To identify the wetlands, I have followed some indicators. The indicators are Size, Regular shape, Irregular shape, Tone or Color, Pattern, Shadow, Association (with settlement), Road Aline (along the roadside), and lowland area (beside the marsh land).

199 water bodies were identified properly, and 7 others no longer existed. and 126 new water bodies were identified. The total number of water bodies is now 325.

4.10. Characteristics of Surface Water Bodies

The founding water bodies are categorized into two major sectors. They are ‘Natural Water Bodies’ such as River and Beel or Marsh and another is ‘Manmade Water Bodies’ such as Khal, Doba and Pond. The main waterbody, River is perennial and the common property of this area as well as seasonal Beels. Most of the ponds are perennial, and they are used for household and fisheries. Most of the Khal, Beel, and Doba are seasonal.

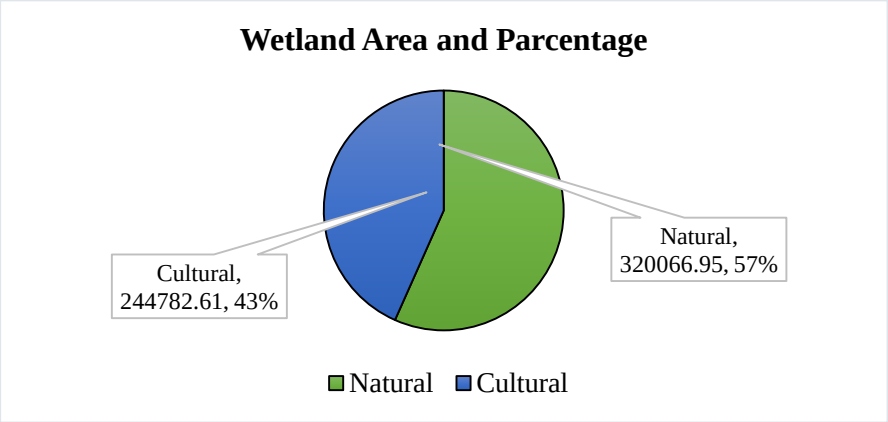


Figure: Wetland Area and Percentage According to Nature

4.11. Types of Surface Water Bodies

The major identified water bodies are rivers and Beels as natural features; Khal, Doba, and Pond were found as cultural features. Ponds are the major feature in this area, which is up about 35.53%, and then Perennial rivers occupy 30.65 and seasonal beels are 26.02%. Area of River is 173104.6 squere meters, Beels are 146962.1 squere meters, Khals are 85516.5 meter2, Dobas are 35516.5 squere meters and Ponds are 200669.9 square meters.

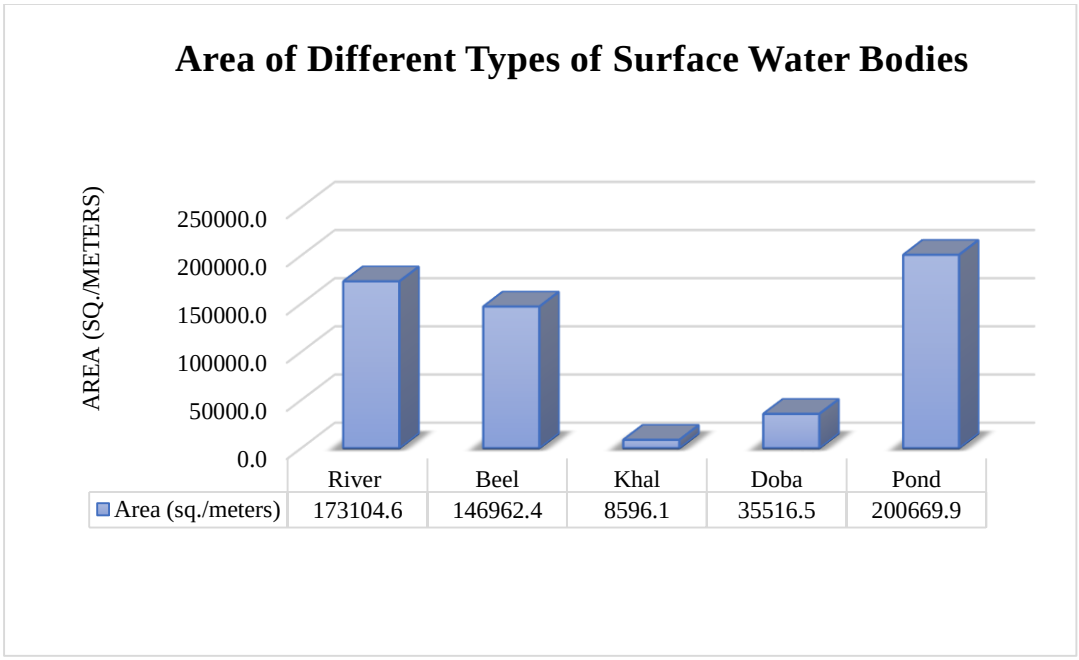


Figure: Area of Different Types of Surface Water Bodies.

4.12. Origen of Wetlands in-between 1970 and 2017

By processing and arranging this data, an organized tabulate data as well as different diagrams were found. On or before 1970, there were only 29 wetlands in this area, that's about 336466.28 square meters, most of them are natural. Between 1971 and 1980, 27655.62 squere meters of land were transformed into wetland, 21900.66 squere meters transformed in-between 1981 and 1990, 134063 square meters in-between 1991 and 2000, 42829.27 square meters in-between 2001 and 2010, and only 1934.36 square meters transformed from 2011 to 2017. Due to the massive flood in 1998 it increase the transformation of land into wetland in between1991 and 2000.

The total area of wetland was gradually increasing till 2010 and then suddenly fall. The possible causes can be use of existing wet lands by reshaping and re-digging in different purpose.

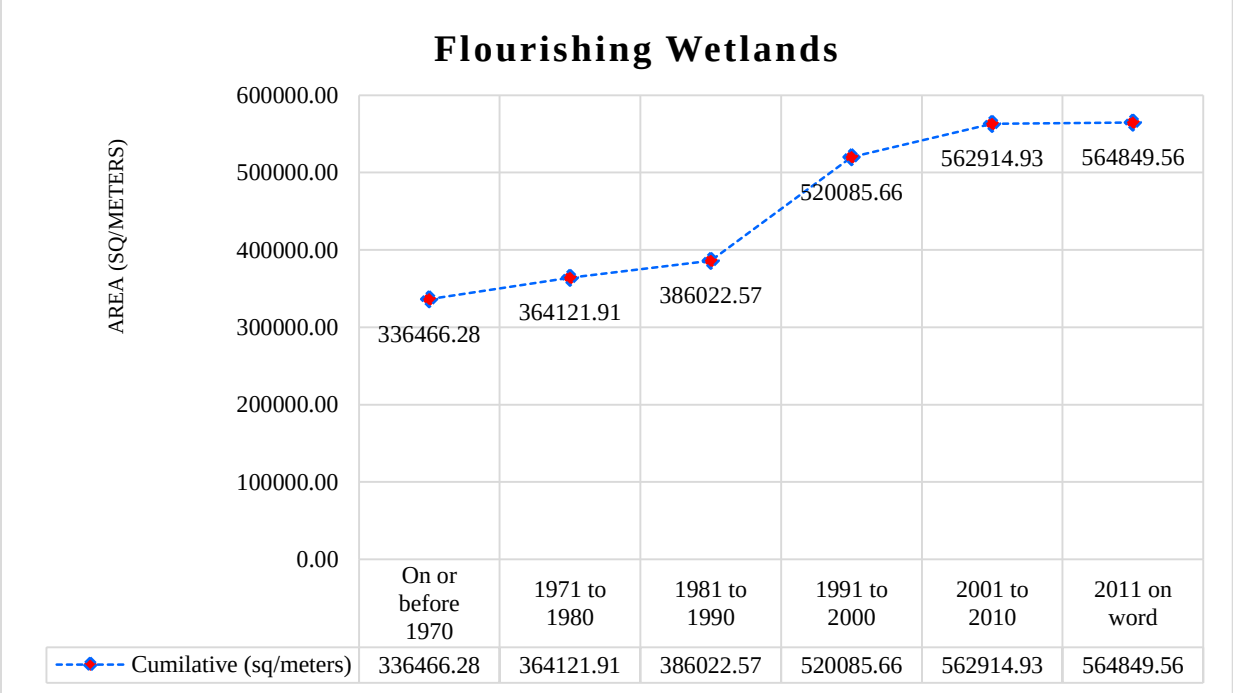
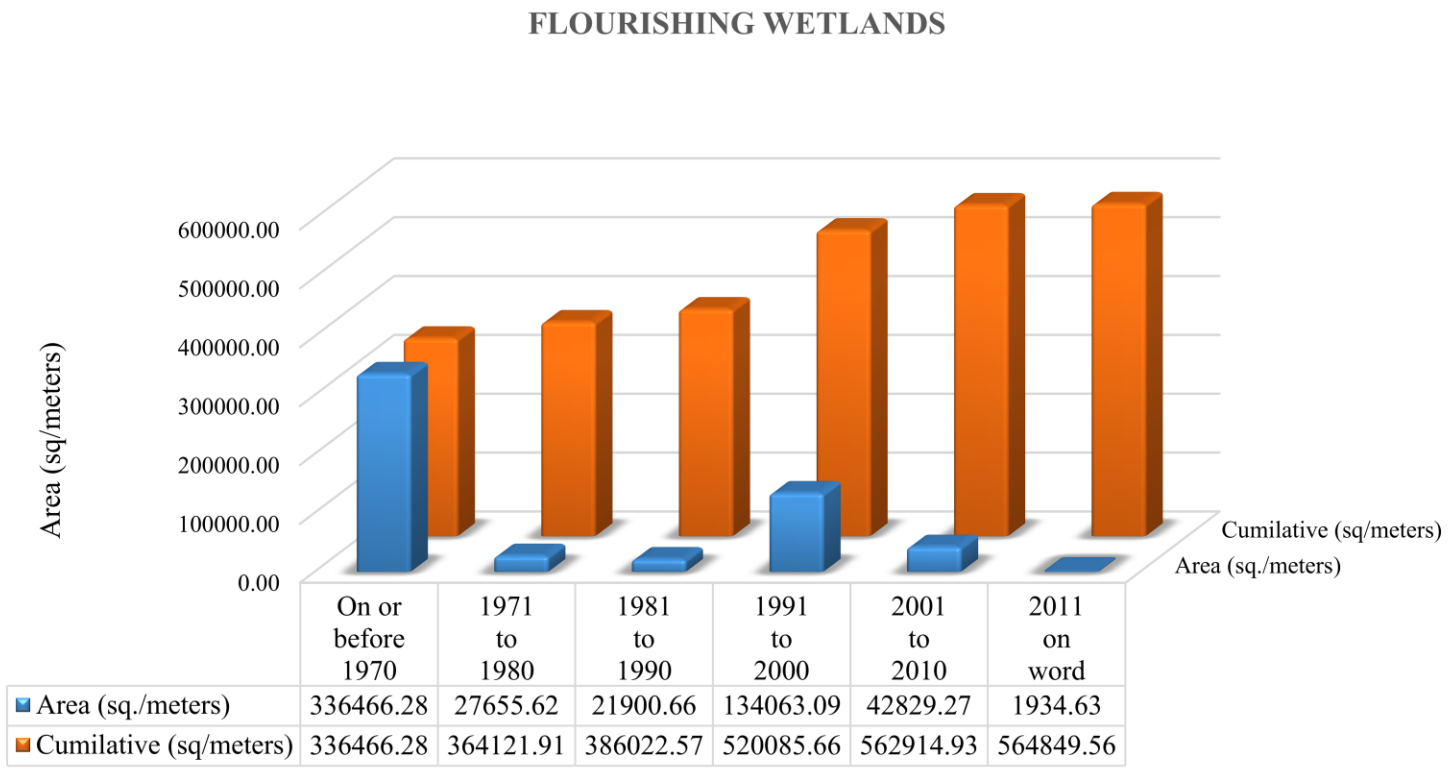


Figure: Flourishing Wetlands in-between 1970 and 2017



	On or before 1970	1971 to 1980	1981 to 1990	1991 to 2000	2001 to 2010	2011 on word
Area (sq./meters)	336466.28	27655.62	21900.66	134063.09	42829.27	1934.63
Cumilative (sq/meters)	336466.28	364121.91	386022.57	520085.66	562914.93	564849.56

Figure: Flourishment of surface water bodies since 1970 to 2017

4.5 Characteristics of Surface Water Bodies

By the availability of water in different times of the year, wetlands are divided into two major types. Perennial Wetland and Seasonal Wetland. Seasonal wetlands are also divided into two types they are S1 (Seasonal: June to February) and S2 (Seasonal: July to October). There are 168 perennial about 374921.71 square meters; 62 Seasonal (June-February)/S1 water bodies, about 162922.45 square meters; and 95 Seasonal (July-October)/S2 water bodies, about 26516.40 square meters in the study area. Almost 62 seasonal wetlands hold water from early rainy season to late winter (June to February), and other 95 hold water only in late rainy season (July to October).

According to the pie chart, we can see that 66 percent of water bodies are perennial; they hold water year round, and most of them are used for household and fisheries. On the other hand, only 29 percent of waterbodies hold water for almost 6 months (June to February) in the rainy season. Another 5 percent only inundates in depth rainy season (July to October).

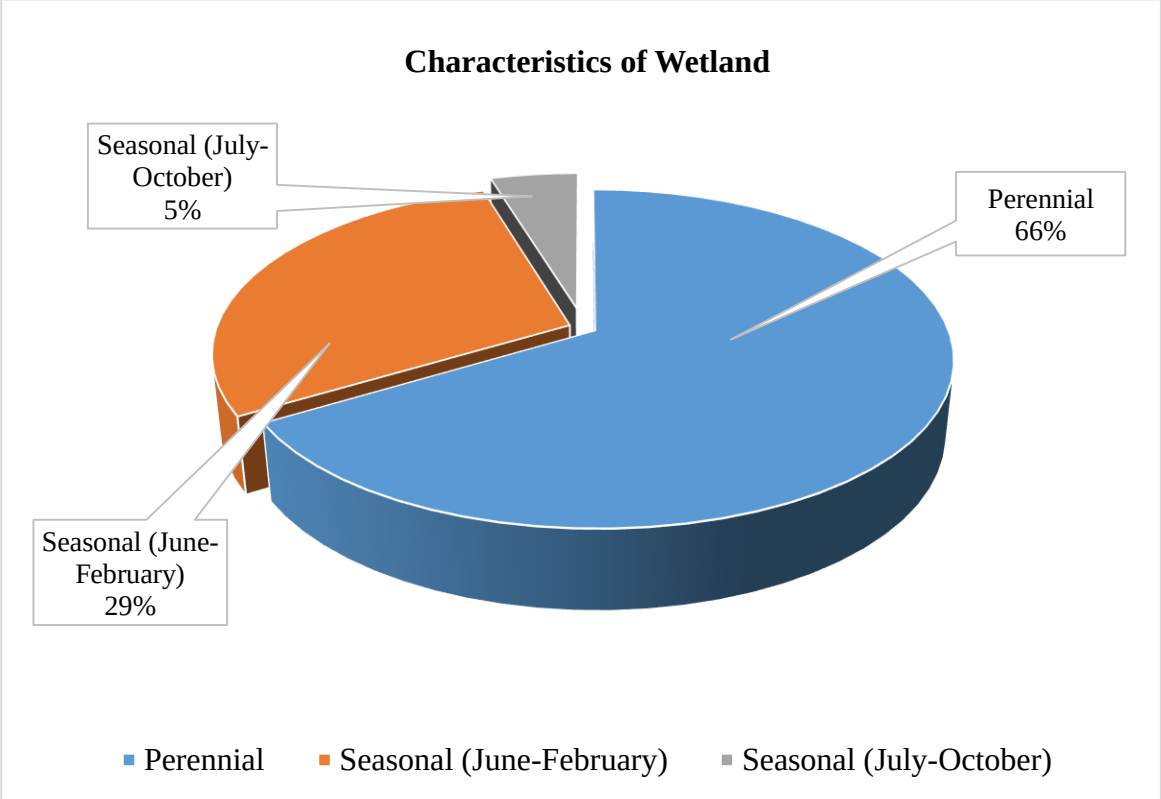


Figure: Percentage of water bodies by their characteristics.

4.13. Ownership of Wetlands

There are three types of ownership found for the existing water bodies in this locality. Among them, 37.61 percent are multiple ownership, most of them management by joint venture, 31.13 percent are single ownership that managed by landholder. And 31.26 percent are government properties that act as common property and are used in various ways.

Rivers and Beels are the major common properties in this area. Beels are seasonal, but the river is used as a common property year-round. Marginal people use Beels as a common properties traditionally but the excess gradually reduce day by day. Constructed ponds are taking place in this beels area, and they become personal properties. As a result, it endangered the local flora and fauna. As constructed wetland is only used for commercial purposes, the local fish cannot grow there.

Table: Number of wetlands and their ownership

Types of Ownership	Number	Area (sq./meters)	Percentage
Government	12	176576.8445	31.26%
Single	151	175824.122	31.13%
Multiple	162	212448.5941	37.61%
Total=	325	564849.5605	100%

4.14. Management of Wetlands

Most of the privet water bodies are managed by single or multiple efforts. However, the common properties are managed cooperatively. Nearly 180748 squere meters are managed by a single effort, 113327 squere meters are managed by Multiple and the rest, 270773 squere meters area is managed cooperatively. According to the criteria of management, the wetland management proportion is- 47.9 % are cooperative, 32% are single, and 20.1 % are multiple management.

Table: Management of wetlands by area and their percentage

Management of Wetlands	Area (sq./meters)	Percentage (%)
Single	180748.44	32.0
Multiple	113327.42	20.1
Cooperative	270773.70	47.9
Total=	564849.56	100%

4.15. Uses of Wetland

Water bodies are used in various ways. Most of all are used in households, fisheries,s and others e.g., bathing, transportation, performing of ritual etc. More than 96 percent of water bodies are used for different household works, 47.74% are used for irrigation in fields, 31.92 % are used for factories, and most of the water bodies are used for fisheries and other purpose.

Table: Number of wetland and their uses

Uses of Wetland	Number	Area (sq./meters)	Percentage
Household	289	545123.70	96.51%
Irrigation	57	258378.81	45.74%
Factory	4	180290.68	31.92%
Fisheries	197	526050.17	93.13%
Others	260	534102.44	94.56%
Total=	325	564849.56	100%

Total Area of weatland are 564849.56 squere meters that use in many ways. The percentage of use of wetland given below-

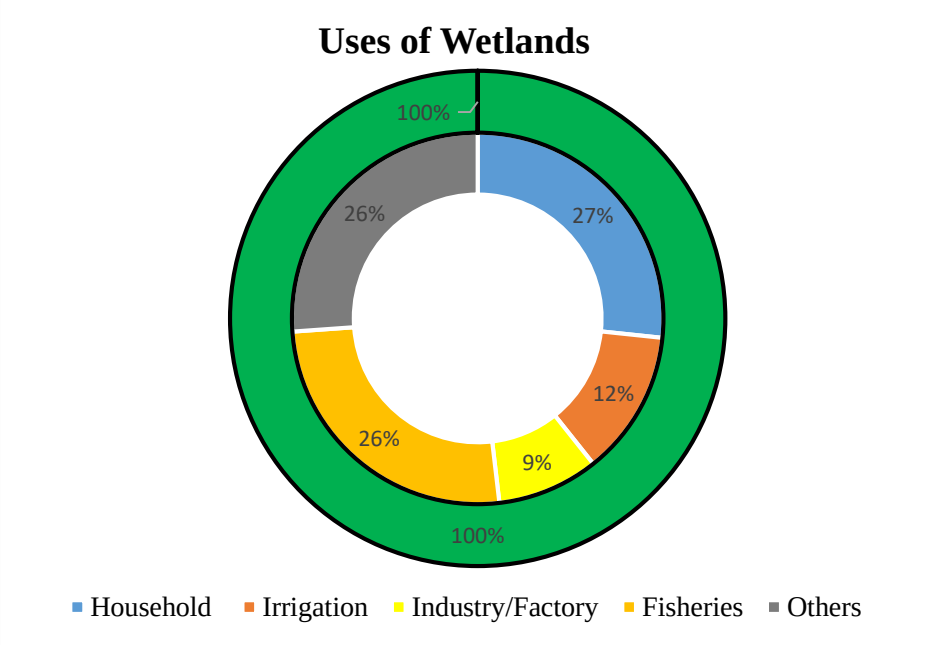


Figure: Percentage of wetland and their uses

5

Chapter Five: Changes in Surface Water Bodies in Study Area

Chapter contents

5. Changes in Surface Water Bodies in Study Area

5.1. Changing Nature of Surface Water Bodies

5.2. Changes in Surface Water Bodies

5.3. Changes in Constructed Surface Water Bodies Over the time

5.4. Causes Behind the Changes

5.4.1 Natural Causes

5.4.2 Manmade Causes

5. Changes in Surface Water Bodies in Study Area

As an active part of the Ganges River Floodplain, Brihospotipur was naturally flooded and played a function as an alluvium land in the decades of the seventeenth and eighteenth centuries. Agricultural lands were uniformly fertilized in natural ways. Soli contained sufficient moisture to grow crops. Relatively low lands were flooded in the monsoon season, and they became common properties to the marginal people. In the dry season, these lands were used for agricultural production. There was an equilibrium that circled rhythmically. But in 1992, the Pabna Irrigation and Rural Development Project (PIRDP) was developed for flood control. As a result, the seasonal flooded and deathly flooded lowlands that remain 4 to 6 months under water up to a depth of 90 to 180 cm are no longer inundated. Extensive floodplain that turns into wetlands have now become dry land. On the other hand, it produces an additional 1 lakh and 91 thousand metric tons of crops per year, providing irrigation facilities in more than 18 thousand and 680 hectares of land (Bangladesh Water Development Board, 2005).

Taking advantage of flood-free conditions, new households are emerging rapidly. One crop land became two or three crop lands, and crop production gradually increased. Non-flooding conditions do not help enrich soil with new silts, and now farmers are facing some issues in the new conditions. They are trying to adapt to this new condition.

5.1.Changing Nature of Surface Water Bodies

In most cases, the natural characteristics of surface water bodies in Brihospotipur have changed. With the implementation of the Pabna Irrigation and Rural Development Project (PIRDP), the study area became enclosed with high embankments that protect the study area from flood. As a result, the local hydrology of Brihospotipur has greatly changed. Perennial wetlands became seasonal wetlands, seasonal wetlands became dry lands, and a single entity of wetlands separated into multiple entities.

By the study of SRDI report and other document I'm able to identify six types of lands in the pre-embankment condition. The lands are High Land (H), Medium High Land (MH), Medium Land (M), Medium Low Land (ML), Low Land (L), and Perennial Wet Land (P). Each land had varied flood depth and duration. There occurred massive flood for a long time in this lands. With the implementation of the PIRDP project, the high lands and medium high lands have become totally flood free zoon, Medium land inundate in Shrabon-Bhadro month by a water depth of 30 cm.

Medium low land and low land are now inundate by a water depth of 60 cm to 120 cm in peak wait season. A vast area come under cultivation which was affected by flood.

The comparable changes are marked as inundation level change and change in duration of inundation of different types of lands in pre-project condition and post-project condition.

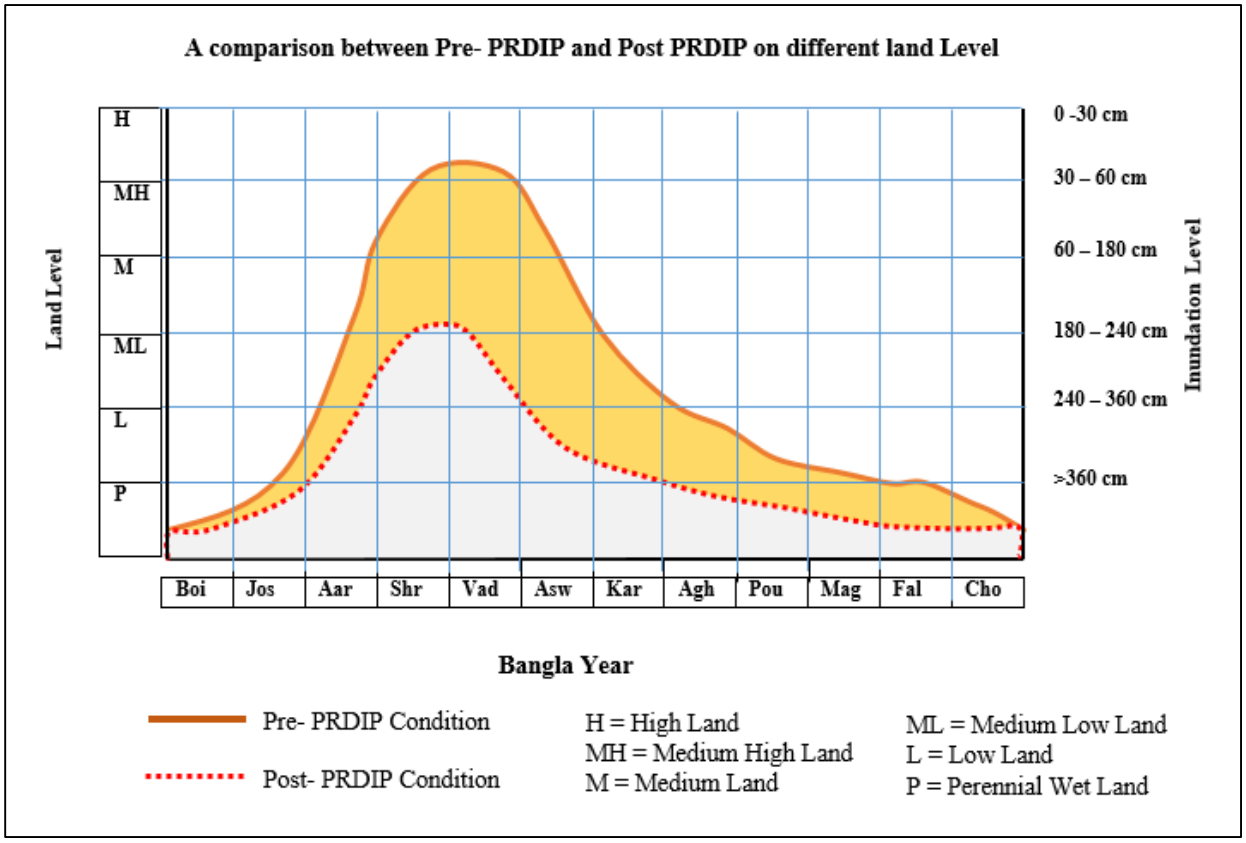


Figure: A comparison between Pre-Project condition and Post-Project condition on different land level and inundation level of Brihospotipur.

Inundation level and time have changed over the time for the implementation of Pabna Irrigation and Rural Development Project (PIRDP). The inundation level of different land levels decreases on one side, inundation time also decreases on the other side. In post-PIRDP conditions, especially high land and medium high land have become flood-free when they were flooded in pre-PIRDP condition. In the pre-project condition, the duration of the flood was 4 to 6 months, and now it is about 7 days to 1 month. In this time, only low lands or marshes are flooded by a water depth of 60 to 120 cm with the time of 7 to 30 days.

Table: A comparison between Pre-Project condition and Post-Project condition on different land level and inundation level of Brihospotipur.

Bangla Month	Land Level and Inundation Level (cm)											
	Pre-PIRDP Condition						Post-PIRDP Condition					
	H	MH	M	ML	L	P	H	MH	M	ML	L	P
Boishakh	-	-	-	-	-	30-120	-	-	-	-	-	30
Jyoishtho	-	-	-	60	90	180	-	-	-	-	30	90
Asharh	30	30	60	90	120	≥240	-	-	-	60	90	120
Shrabon	30	60	120	180	240	≥360	-	-	30	120	180	≥180
Bhadro	-	30	90	120	200	≥360	-	-	30	120	180	≥180
Ashshin	-	-	60	100	180	≥360	-	-	-	60	120	≥180
Kartik	-	-	-	60	120	≥240	-	-	-	30	90	120
Ogrohayon	-	-	-	30	90	180	-	-	-	-	60	90
Poush	-	-	-	-	30	120	-	-	-	-	-	60
Magh	-	-	-	-	-	90	-	-	-	-	-	30
Falgun	-	-	-	-	-	60	-	-	-	-	-	-
Choitro	-	-	-	-	-	30	-	-	-	-	-	-

Source: SRDI report and Author.

5.2.Changes in Surface Water Bodies

In the study area, the changes can be shown in two ways. One can be seasonal variation and anther can be over the time. In the pre-project condition, most of the lands of Brihospotipur are flooded in the wet season and normally cultivated through the rest time. On the other hand, in the post-project condition, only low lands or the ground of the marshes only inundated by accumulated rain water, but the rest of the lands remain flood-free. A vast part of this flood plain become dry land. Over time, taking advantage of flood-free condition settlements are expanded, and other infrastructural development took place. Agricultural practices are spread out from the high land to natural depression. Before 1992, natural depression or marsh land had played a role as a common property, but nowadays marsh land has become private estate. Marginal people become looser as they have no access to fishing and other.

A set of maps is given next page to show the conditions of wetlands in different seasons.

5.3.Changes in Constructed Surface Water Bodies Over the time

The constructed water bodies or ponds were gradually increased over time. Most of the ponds are used for fisheries. There are other types of manmade wetlands known as Doba. Doba has no constructed boundary and dug for supply of soil purpose of settlement not for fisheries. Channels are the narrow and shallow wetlands dug for linkage to the marshes. Ditches were constructed for the road. In 1970, there were a few acres of constructed water bodies, but it gradually increased over time. In 2017, the area of constructed water bodies was about 34.9 acres. The natural water bodies' marshes are about more than 62 acres, and the area of the part of the river is about 42 acres. A tabulate data sheet shown below represents the flourishment of constructed wetlands in this area.

Table: Show the area of constructed wetlands with the river and marshes by the different period of time in Brihospotipur.

Construction Years	Area of Constructed Wetlands (Acres)	Area of River (Acres)	Area of Marshes (Acres)	Total Area (Acres)
On 1970	3	42	62	107
1970-1980	9.7			113.7
1970-1990	13.4			117.4
1970-2000	20.8			124.8
1970-2010	28.6			132.6
1970-2017	34.9			138.9

Although the area of river and marshes were change over the time but in this chart is show only a specific area. The river area has no remarkable change over time, so we take a mean area of the river. On the other hand, for the marshes, it calculates only the ground of the valley, the lowest parts of the marshes. There are two marshes or Beels in the study area of roughly 62 acres.

A set of maps is shown on the next page to show the flourishment of the constructed water bodies in Brihospotipur between 1970 and 2017.

5.4.Causes Behind the Changes

There are many causes of wetlands transformation that are associated with the development activities, e.g., settlement expansion, increase the cultivable land, structural development, and so on. Other causes are related to socio-economic conditions, for example, population growth, demand of fish, high rate of return from fisheries, etc. The causes of surface water bodies' changes are divided into two major types. Natural causes and manmade causes. Changes caused by natural ways take place slowly and have little harm on nature, but changes brought out by human interaction are rapid and most of the time have negative effects on human beings and nature. The major natural and manmade causes of surface water bodies' changes are:

5.4.1 Natural Causes

The natural causes of surface water bodies change can be siltation on the river bad, natural barrier on channels, change of river courses, natural improvement of channels, natural transformation of basin area, hydrological disruption in upper part of basin, channelization in natural ways, siltation with massive flood, drought and other natural phenomena.

Manmade Causes

Surface water bodies are changing their phase as a result of human activities. Wetlands have been changing with the earth's surface by the effects of human activities. The growth of the human population increases settlements, rail, roads, markets, schools, colleges, and other structures. In the last three decades in Brihospotipur, a large area has gone under human settlement. With the increase settlement in develop the local roads and other infrastructure. Man tried to control flood by dam and thereby they can able to increase the cultivable land. On the other hand, a huge number of constructed water bodies take place in the purpose of fisheries:

i. Settlement expansion
ii. Infrastructural development
iii. Increase of agricultural land
iv. Industry and factories
v. Brick fields etc.

6

Chapter Six: Impact of Changes in Surface Water Bodies in Study Area

Chapter contents

6.1 Impact of Changes in Surface Water Bodies in Study Area
6.2 Impact on Physical Environment
- 6.2.1 Impact on Biodiversity
- 6.2.2 Impact on Water
- 6.2.3 Impact on Land

6.1 Impact of Changes in Surface Water Bodies in Study Area

Surface water bodies are the vital component of an ecosystem. They play an important role in carrying the natural environment properly. Surface water bodies provide shelter for huge members of flora and fauna. If somehow, it somehow damages the water bodies, that means it must damage the existing life. The extraction of wetlands is another name for the extraction of wildlife. People are facing some problems that appear in this locality due to the expansion, diminution, and extraction of surface water bodies. The transformation of the wetland has long-term effects on this area. The visual impacts are on biodiversity, water bodies, land, agriculture, fisheries, economy, and even on the cultural environment.

6.2 Impact on Physical Environment

The physical environment means the air, water, soil, vegetation, weather, and other biotic and abiotic components of nature. The physical environment is affected by the changes in surface water bodies in this area. As the physical components of the environment are directly connected with surface water bodies, the soil, water, flora, and fauna have become major victims. The major disruption appears in the local biodiversity of Brihospotipur through the years. An enriched aquatic ecosystem almost going to disappears. The equilibrium of the natural environment does not exist, and the balance of the natural system is also disrupted, although it is not possible to understand in a local context.

6.2.1 Biodiversity

In pre-PRDIP, there was an enriched aquatic ecosystem in this area, but post-PRDIP, they are going to be destroyed. The main causes of the threat of biodiversity are destruction of habitats, fragmentation of habitat, over-exploitation of natural resources, water pollution, soil degradation, deforestation, settlement expansion, massive cultivation and use of prevalent insecticide and fertilizer. Wetland transformation accelerated this process, and great changes took place in local biodiversity.

The losses of wetlands due to flood-free conditions have caused habitat destruction. A large number of water born flora and fauna has become totally disappear from Brihospotipur. Some of the water born flora and fauna are facing threat still now.

In 2000, the International Union for Conservation of Nature (IUCN)-Bangladesh first published the IUCN Red List of Threatened Species Bangladesh. Fifteen years later, the list has been updated to include two invertebrate groups: crustaceans and butterflies.

According to this report, in 2015, 9 species of fishes were in Critical Endangered (CR), 30 species of fishes that were in Endangered (EN), and 25 species of fishes ware in Vulnerable (VU) in this area. In 2000, there were 12 species of fishes ware in Critical Endangered (CR), 28 species of fishes ware in Endangered (EN) and 14 species of fishes ware in Vulnerable (VU) in this area. (Red List of Bangladesh: Freshwater Fishes, 2015)

Table: Status of Threatened Freshwater Fishes in Study Area

Status	Scientific Name	Local Name
Vulnerable (VU)	Anguilla bengalensis	Bao Baim/Boa Baim
	Gudusia chapra	Chaipla/Suiya
	Chela cachius	Chhep chela
	Danio dangila	Gofi Chela
	Labeo ariza	Bata
	Pethia ticto	Tit punti
	Lepidocephalichthys annandalei	Puiya
	Lepidocephalichthys irrorata	Puiya
	Sicamugil cascasia	Kachki
	Awaous grammepomus	Shil Baila/Bele
	Sperata aor	Air/Ayre
	Wallago attu	Boal
	Monopterus cuchia	Kuchia/Cuchia
	Barilius tileo	Tila/ Tila Koksa
	Barilius barna	Koksa
	Crossocheilus latius	Kala Bata
	Oreichthys cosuatis	Kosua punti
	Tor putitora	Mohashol
	Schistura sikmaiensis	Dari

Endangered (EN)	Botia dario	Rani Mach
	Botia lohachata	Beti
	Chitala chitala	Chital
	Channa marulius	Gajar
	Batasio tengana	Tengra
	Ompok bimaculatus	Kani Pabda
	Ompok pabda	Pabda
	Clupisoma garua	Ghaura/Gharua
	Mastacembelus armatus	Baim/Sal Baim
Critically Endangered (CR)	Labeo boga	Bhangan bata
	Labeo nandina	Nandi
	Tor tor	Mahsheer
	Schistura corica	Khorka/ Khorki
	Channa barca	Tila Shol
	Ompok pabo	Kala Pabda

Source: International Union for Conservation of Nature (IUCN)

IUCN Bangladesh also published the first Red List of Threatened Animals of Bangladesh in 2000. The list has been updated through a sub-project entitled 'Updating Species Red List of Bangladesh' under the 'Strengthening Regional Cooperation for Wildlife Protection (SRCWP)' Project of the Bangladesh Forest Department. The threatened animals are-

Table: Status of Threatened Mammals in Study Area.

Status	Scientific Name	Local Name
Regionally Extinct (RE)	Neofelis nebulosa	Gecho Bagh
	Aonyx cinerea	Bhodar
	Vulpes bengalensis	Khek Shia
	Arctonyx collaris	Balu-shuor
	Sus scrofa	Buno Shukar
	Platanista gangetica	Shishu/Shushuk/Susu/Shush
	Tamiops macclellandii	Dorakata Kathbirali
	Prionailurus viverrinus	Mechho Bagh

Endangered (EN)	Tupaia glis	Gecho Chhucho
	Felis chaus Schreber	Ban Biral/ Gara
Near Threatened (NT)	Viverra zibetha Linnaeus	Baghdas/ Khatas
	Viverricula indica	Gandho Gakul/Choto Bagdash
	Hystrix indica Kerr	Shojaru
Least Concern (LC) Least Concern (LC)	Bandicota bengalensis	Khet-indur
	Bandicota indica	Dhari Indur
	Vandeleuria oleracea	Gecho Nengti Indur
	Funambulus pennantii	Dora Kathbirali
	Megaderma lyra	Chamchika
	Herpestes auropunctatus	Chhoto Beji

Source: International Union for Conservation of Nature (IUCN)

Table: Status of Threatened Birds in Study Area.

Status	Scientific Name	Local Name
Regionally Extinct (RE)	Francolinus gularis	Bada Titir
	Asarcornis scutulata	Badi Hash
	Antigone antigone	Sharosh
	Ardea insignis	Dholapet-bok
	Sarcogyps calvus	Kalo Shokun
Endangered (EN)	Clanga hastata	Deshi Guti-eegol
	Ciconia nigra	Manikjor
	Psittacula finschii	Tia
	Ixobrychus flavicollis	Kalo Bok
	Vanellus duvaucelii	Nodi Titi
	Vanellus malabaricus	Holdegal Titi
	Limosa lapponica	Dagilej Jourali
	Nettapus coromandelianus	Bele Hansh
	Mareca strepera	Piang Hash
	Podiceps grisegena	Lal-gola Duburi
	Spilopelia chinensis	Tila Ghughu

Near Threatened (NT)	Cypsiurus balasiensis	Talbatashi
	Clamator coromandus	Khoirapakh Papia
	Eudynamys scolopaceus	Kala Kokil
	Hierococcyx varius	Pati Chokgelo
	Ardeola grayii	Kani Bok

Source: International Union for Conservation of Nature (IUCN)

Table: Status of Threatened Reptiles and Amphibians in Study Area.

Status	Scientific Name	Local Name
Regionally Extinct (RE)	Batagur dhongoka	Dhoor Kachhim
	Batagur kachuga	Kori Kaitta
	Chitra indica	Chim Kachhim
	Hardella thurjii	Kali Kaitta
Endangered (EN)	Nilssonia gangetica	Ganga Kachhim
	Melanochelys trijuga	Kali Kachchop
	Morenia petersi	HaldeyKaitta
	Pangshura smithii	Bora Kori Kaitta
	Lygosoma lineolatum	Dorakata Anjon
	Varanus bengalensis	Gui Shap
	Varanus flavescens	Sona Gui
	Bungarus lividus	Choto Kalo Kewtey
	Bungarus niger	Kalo Kewtey
	Bungarus walli	Waler Keutey
	Naja kaouthia	Gokhra Shap
	Naja naja	Khoia Gokhra
	Daboia russelii	Chandra Bora
	Pangshura tecta	Kori Kaitta
	Lissemys punctata	Shundhi Kasim
	Calotes versicolor	Roktochosa
	Gekko gecko	Tokkhak
	Hemidactylus flaviviridis	Tiktiki
	Hemidactylus frenatus	Mosrin Tiktiki
	Eutropis carinata	Anjon/Anchil

Near Threatened (NT)	Eutropis dissimilis	Dora-kata Anjon
	Eutropis multifasciata	Dagi Anjon
	Lygosoma bowringii	Bowringer Anjan
	Ahaetulla prasina	Laodoga Shap
	Lycodon aulicus	Gharginni Shap
	Ptyas mucosa	Darash Shap
	Amphiesma stolatum	Dora Shap
	Atretium schistosum	Maitta Shap
	Xenochrophis cerasogaster	Kalo Mete Dhora
	Xenochrophis piscator	Dhora Shap
	Bungarus caeruleus	Kal Keutey
	Ramphotyphlops braminus	Dumukha Shap
	Indotyphlops jerdoni	Jerdoner Dumukha Shap
Near Threatened (NT)	Duttaphrynus melanostictus	Kuno Bang
	: Euphlyctis cyanophlyctis	Kotkoti Bang
	Fejervarya asmati	Jhi-jhi Bang
	Fejervarya syhadrensis	Bon Jhi-Jhi Bang
	Boro Kot-koti Bang	Boro Kot-koti Bang
	Hoplobatrachus tigerinus	Sona Bang
	Hylarana tytleri	Pana Bang
	Polypedates leucomystax	Dorakata Gecho Bang

Source: International Union for Conservation of Nature (IUCN)

6.2.2 Water

A vast area of floodplain has become dry land. As a result, the ecosystem and soil characteristics of this area have changed. Most of the perennial water bodies become almost dry, especially in the dry season. The marshes are gradually losing their areal extent. The smaller water bodies cannot merge, and they become degraded. Flood water refreshed the degraded wetland water by natural ways in pre-project condition, but now the water of inland bodies cannot be refreshed.

Most of the agricultural land is irrigated by grown water in the dry season as a result, it gradually loses the capacity of pumps to serve water. Ground water level gradually getting down and they have a negative impact on whole surface water bodies. Flooding conditions help to recharge the ground water; by now, the flood-free condition does not do it.

The most negative effects become visible on the common properties that were enjoyed by people as traditional rights for own consumption. As the local marginal people cannot allow to access in marshes for fishing and the collection of other natural resources, they become looser.

There are two beels in the study area name Kana Beel and Baysar Beel. Due to surface water bodies changing, these two beels have been losing their areal extent. The decreasing areal extent of two beels are given bellow

Table: Show the gradually decreasing in areal extent of marshes in study area.

Name of Beels	Areal Extent in 1970		Areal Extent in 2017	
	Wet Season	Dry Season	Wet Season	Dry Season
Kana Beel	3.76 km^2	0.79 km^2	0.47 km^2	-
Baysar Beel	5.39 km^2	1.36 km^2	1.3 km^2	-

6.2.3 Land

In the pre-project condition, it occurred flood in every year, and this soil could be fertilized in natural ways. Siltation of agricultural land helps the soil to grow sufficient crops. It needs no fertilizer to grow crops, but non-flooding conditions do not help enrich soil with new silts, and still now farmers are facing some issues in the new condition. An uneven fertility can be found in different sides in a field.

On the other hand, high land and medium high land don't get sufficient moisture to grow crops in the dry season due to unavailable surface water bodies. Most of the agricultural land is irrigated by grown water in the dry season as a result, it gradually loses the capacity of pumps to serve water. Ground water level gradually getting down and they harm whole surface water bodies. Flooding conditions help to recharge the ground water by now the flood free condition does not do it.

On the one side agricultural lands cannot get chance to be fertilized in natural on the other hand it use fertilizer and chemical insecticide for cultivation. And thereby people degraded soil. In flooding condition agricultural land ware inundated and soil could get chance to refresh but it is become very rear.

Conclusion

The study of wetland transformation in the Brihospotipur area and its adjoining regions reveals the intricate interplay between environmental changes and socioeconomic development. Wetlands, as vital ecological and economic resources, have undergone significant transformations due to both natural processes and human interventions, particularly through projects like the Pabna Irrigation and Rural Development Project (PIRDP). While these changes have brought about increased agricultural productivity, settlement expansion, and infrastructural development, they have also raised pressing concerns about biodiversity loss, environmental degradation, and socio-economic disparities.

The findings underscore the dual nature of wetland transformation—offering opportunities for development while simultaneously posing challenges to sustainability. The shift from seasonal wetlands to dry lands has altered traditional livelihoods, impacted ecological balance, and introduced new agricultural practices that require adaptation. Marginalized communities, in particular, have faced difficulties as common resources have become privatized, and biodiversity has been threatened by increased use of fertilizers and pesticides.

This study highlights the importance of documenting and understanding wetland transformations at a local scale to address site-specific challenges effectively. By identifying the driving forces behind these changes and their consequences, policymakers and stakeholders can work toward sustainable wetland management strategies. Balancing development needs with ecological preservation is essential to ensure that wetlands continue to serve as critical resources for both people and the environment.

In conclusion, the transformation of wetlands in Brihospotipur serves as a microcosm of broader environmental and socio-economic dynamics in Bangladesh. It calls for integrated approaches that prioritize ecological sustainability while addressing the needs of local communities. Future research and policy efforts should focus on mitigating adverse impacts, promoting adaptive practices, and preserving the invaluable functions of wetlands for generations to come.

Recommendations

Based on the findings and analysis of wetland transformation in Brihospotipur and its adjoining areas, the following recommendations are proposed to ensure sustainable wetland management while balancing socio-economic development and environmental preservation:

1. Adopt Sustainable Wetland Management Practices

Establish community-based wetland management systems to involve local stakeholders in decision-making processes. Promote traditional practices that maintain ecological balance, such as seasonal flooding and natural fertilization.

2. Implement Policies to Protect Biodiversity

Enforce regulations to limit the use of harmful fertilizers and pesticides that threaten biodiversity. Designate ecologically sensitive areas as protected zones to conserve native flora and fauna.

3. Promote Awareness and Education

Conduct awareness campaigns to educate local communities about the importance of wetlands and their ecological functions. Provide training programs for farmers on sustainable agricultural practices that minimize environmental impact.

4. Encourage Research and Monitoring

Initiate regular monitoring programs to document changes in wetland ecosystems and their driving factors. Support research on innovative techniques for wetland restoration and adaptation to changing conditions.

5. Develop Integrated Development Plans

Balance development projects, such as irrigation and flood control, with measures to preserve wetland ecosystems. Ensure that development initiatives include environmental impact assessments (EIAs) and mitigation strategies.

6. Support Livelihood Diversification

Introduce alternative livelihood options for marginalized communities affected by wetland transformation, such as eco-tourism or aquaculture. Provide financial incentives or subsidies for adopting environmentally friendly practices.

7. Strengthen Institutional Frameworks

Enhance coordination between government agencies, NGOs, and local communities for effective wetland management. Develop clear policies and guidelines addressing ownership, access rights, and resource sharing in transformed wetlands.

By implementing these recommendations, it is possible to mitigate the adverse effects of wetland transformation while harnessing its potential benefits for socio-economic development. A collaborative approach involving all stakeholders is essential to ensure the long-term sustainability of wetlands in Brihospotipur and beyond.

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